H2020-LCE-2016-2017

EUROPEAN COMMISSION

European Climate, Infrastructure and Environment Executive Agency (CINEA)

Grant agreement no. 731249

SMILE

Smart Island Energy Systems

Deliverable D7.4
Balancing Local Grids

Document Details

Due date	30-04-2021
Actual delivery date	30-06-2021
Lead Contractor	University of Groningen (RUG)
Version	Final rev0
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Reviewed by	DTI, Samsø Energy Academy, Community Energy Scotland, Route Monkey, OVO (Kaluza), EEM, RINA Consulting
Dissemination Level	Public

Project Contractual Details

Project Title	Smart Island Energy Systems
Project Acronym	SMILE
Grant Agreement No.	731249
Project Start Date	01-05-2017
Project End Date	31-10-2021
Duration	54 months

The project has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 731249

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List of abbreviations

aFRR	automatic Frequency Restoration Reserve
BEIS	Department for Business, Energy and Industrial Strategy
BRP	Balance responsible party
BSP	Balancing service provider
CMZ	Constraint Managed Zones
DC	Dynamic Containment
DC NC	Network code on demand connection
DL	Decree-Law
DNO	Distribution network operator
DR	Demand Response
DSO	Distribution system operator
EB GL	Electricity balancing guideline
ENA	Energy Networks Association
EV	Electric vehicle
FCR	Frequency containment reserve
FCR-D	Frequency-controlled disturbance reserve
FCR-N	Frequency-controlled normal operation reserve
FFR	Fast frequency reserve
FSP	Flexibility service provider
LFM	Local flexibility market
mFRR	manual Frequency Restoration Reserve
MPGGS	*Manual de Procedimentos da Gestão Global do Sistema* - Manual of procedures for the management of the system
MS	Member State
NECP	integrated National Energy and Climate Plan
NGESO	National Grid Electricity System Operator
NRA	National regulatory authority
Ofgem	the Office of Gas and Electricity Markets
PGF	Power-generating facility
PGM	Power-generating module
PV	Photovoltaic
RES	Renewable energy source
RfG NC	Network code on requirements for grid connection of generators
ROR	*Regulamento de Operação das Redes* - Regulation on network operation
RR	Replacement reserves
RRC	*Regulamento das Relações Comerciais* - Regulation on commercial relations
SSEN	Scottish and Southern Electricity Networks
SO GL	System operation guideline
TCMs	Terms and conditions or methodologies of implementation
TSO	Transmission system operator
vRES	variable renewable energy source

Executive summary

The overall scope of the H2020 SMILE project is to demonstrate, in real-life operational conditions, technological and non-technological solutions adapted to local circumstances, with a focus on distribution grids. The project specifically focuses on demand response schemes, smart grid functionalities, storage options and energy system integration, with the final objective of paving the way for the market introduction of the tested innovative solutions in the near future. To this end, three large-scale pilot projects are currently carried out at three island locations: Orkneys (UK), Samsø (DK) and Madeira (PT).

This deliverable investigates how the stability of electricity networks can be maintained when they have to integrate increasing volumes of electricity produced from variable renewable energy sources (vRESs) by installations that are often connected to the distribution grid. At national level, transmission system operators (TSOs) have to cope with this variability in order to maintain network balancing. Apart from traditional methods (e.g., relying on reserve capacity), TSOs can use flexibility resources, including resources connected to the distribution network. At local level, distribution system operators (DSOs) will increasingly procure flexibility services to deal with issues such as congestion or voltage dips on their network. In both cases, the deployment of enablers such as smart meters and energy storage is a necessity. This deliverable presents an in-depth study of the legal regime for balancing and local flexibility markets (LFMs) as well as their enablers in the EU and in the three SMILE demonstrator countries.

Balancing markets in the EU have been harmonised by the 2017 Electricity balancing guideline. These markets are operated by TSOs, which are also the sole buyers of balancing services offered by balancing services providers (BSPs) in order to resolve the imbalances created by balance responsible parties (BRPs) not adhering to their production or consumption schedules. National balancing markets are in the process of being interlinked through European platforms to pool balancing resources and reduce balancing prices. Denmark and Portugal are part of almost all of these (upcoming) platforms, and Great Britain was on its way to integrate two of them before Brexit.

As we make progress in the transition to vRESs, TSOs will need to procure more balancing services provided by flexibility resources connected to the distribution network (hereafter referred to as distributed flexibility resources). Flexibility is a new term introduced in EU law by the Clean Energy Package. Flexibility services are broader in scope than balancing services. They refer to the ability to increase or decrease electricity generation or consumption as requested by flexibility service buyers, including TSOs and DSOs. They include balancing services, but also non-frequency ancillary services, congestion management services or grid investment deferral services.

To increase the quantity of distributed flexibility resources used to provide flexibility services, enabling technologies and activities need to be regulated. These enablers are smart meters, energy storage, demand response (DR) and aggregation. The 2019 E-Directive and 2019 E-Regulation have either reinforced existing legal regimes or introduced new regimes for these technologies and activities. These are now all defined in the 2019 E-Directive. The corresponding transposition into national law for EU Member States (MSs) is on its way. The UK has also made some progress, for instance by launching a balancing market tailored for the supply of services from battery storage installations.

According to the 2019 E-Directive, DSOs must create markets for the procurement of non-frequency ancillary services, of energy to cover their energy losses and of flexibility services (if they want to procure flexibility services at all). There are exemptions, but the rationale is that DSOs have to develop LFMs to procure flexibility services for the operation and development of their grid. The services that

could potentially be exchanged on LFMs fall under various legal qualifications. In addition, the technical and geographical context varies and influences local service needs. These elements may therefore lead to the creation of several LFMs with different rules. Nevertheless, the actors in an LFM will follow the same architecture of roles as that in a balancing market, albeit with some adjustments. In essence, the system operator buys services provided by flexibility service providers (FSPs). However, the system operator here is the DSO, not the TSO, and FSPs are expected to rely substantially on aggregation.

At national level, only the UK is using LFMs. Guided by the ministry and the regulator, distribution network operators (DNOs) have developed LFMs since 2018 to procure a variety of flexibility services. In Denmark, the legal framework has recently improved with the transposition of the 2019 E-Directive, but so far only pilot LFMs are being deployed. In Portugal, the delayed transposition of the 2019 E-Directive has a negative impact on the potential creation of LFMs. With regard to the SMILE islands (Orkney, Samsø and Madeira), the research shows that despite their different situations, these islands are well suited for developing LFMs.

Considering the above, we make the following three series of legal recommendations relating to (i) the use of distributed flexibility resources for balancing service, (ii) the regulation of enablers and (iii) the development of LFMs. These recommendations rely on the timely transposition of the 2019 E-Directive into national law. This transposition was due by the end of 2020, but by June 2021 most of the Directive had not yet been transposed into Portuguese law, including the relevant transpositions for this deliverable. The European Commission can impose legal sanctions when a directive is not transposed or is insufficiently transposed by EU MSs. We reiterate the importance of such procedures given the importance of the key provisions in the 2019 E-Directive relevant for mobilising distributed flexibility resources and developing LFMs.

Improved access of distributed flexibility resources to balancing markets

In order for TSOs in the EU to be able to use as much distributed flexibility resources as possible, the access of these resources to balancing markets should be improved. To achieve this, we make the following three proposals:

Firstly, the 2019 E-Directive, the 2019 E-Regulation and the relevant EU network codes (EB GL, SO GL, RfG NC and DC NC) should be amended in order to ensure effective access to balancing markets by market parties offering distributed small to medium-sized solutions based on storage, DR and aggregation. To this end, these technologies and activities must be expressly authorised in all the aforementioned network codes as well as in the terms and conditions or methodologies of implementation (TCMs) stemming from these codes. Lowering the product requirements (e.g., with regard to the minimum bid size) could also be useful. This requires some further investigation by ENTSO-E and the EU DSO Entity.

Secondly, balancing platforms are being developed on a European (pan-national) scale. However, such a development may be detrimental to the supply of balancing services offered by small and medium-sized installations on a local level, even when aggregated. It may therefore be relevant to introduce a mechanism such as a locational tariff to give value to locally available flexibility resources.

Thirdly, clear and detailed rules are needed to organise priority activation of distributed flexibility resources by TSOs or DSOs. Currently, it seems that the SO GL is prioritising TSOs to activate flexibility resources for balancing markets, albeit with a veto right for DSOs in charge of the networks to which the resources are connected (the so-called reserve-connecting DSOs). Moreover, the network codes require DSOs to provide data to TSOs with regard to the installations connected to their network. TSOs do not have the same obligation towards DSOs. The network codes should be amended in order to request a bidirectional exchange of data (from TSOs to DSOs and vice versa). Indeed, DSOs may also be interested in data managed by TSOs, especially if DSOs are to create LFMs. In addition, the rules on data sharing need to be harmonised. At present, some DSOs share data on a 15-minute basis, while others do it daily, weekly, monthly or apparently not at all.

Regulate enablers

Increased use of distributed flexibility resources can be facilitated by amending the rules for enabling technologies and activities such as smart meters, energy storage, DR and aggregation.

Smart meters are an important means of facilitating the energy transition at the lowest possible cost. To fulfil their role, they need to equip all metering points and provide for a settlement time that is compatible with the possibility of offering services to flexibility markets (including balancing markets and LFMs). In Denmark, the rollout of smart meters was almost completed by the end of 2020. In contrast, Portugal and the UK still had to equip at least half of the metering points with a smart meter at that time. This transition process to smart meters should be completed as soon as possible. Regarding the settlement time, the 2019 E-Directive provides in article 20 (1) (g) that smart meters "shall enable final customers to be metered and settled at the same time resolution as the imbalance settlement period in the national market." This imbalance settlement period is harmonised at EU level by article 53 (1) of the EB GL. According to this provision, TSOs had until the end of 2020 to apply an imbalance settlement period of 15 minutes. The European Commission, with the help of ENTSO-E, should verify whether this is the case. In principle, the smart meters installed in Portugal and Denmark allow for this 15-minute settlement. However, in the UK, which is no longer bound by EU law, only a fraction of the installed smart meters is considered advanced and can facilitate half-hourly settlement periods. Ofgem and BEIS appear to be addressing this issue, but they must ensure that the UK achieves the full rollout of advanced smart meters by the end of 2025 as scheduled.

Energy storage covers a range of technologies to provide flexibility services and allow further penetration of vRESs. At EU level, the EB GL and corresponding TCMs should be amended to allow for a balancing market design that facilitates the participation of energy storage (e.g., through batteries). The UK provides a very instructive example of such a market with its Dynamic Containment market launched in October 2020. This platform requires asymmetrical products and permits battery storage operators to engage in benefit stacking, thus reinforcing their business case and allowing them to offer services where they are most needed (and therefore most remunerated). Denmark also provides an interesting example with its 300-kW minimum bid size on some balancing markets, a threshold more accessible to medium-sized and aggregated storage installations. The possibility of using such facilitating product requirements as standards in balancing and other flexibility markets in the EU should be studied.

DR and aggregation are not as far advanced in the EU as they have only recently been integrated into EU and MS law. As a next step, the barriers they face will need to be addressed. Various reports from 2020 have shown that DR and aggregation are limited in all three SMILE countries for different reasons (e.g., inadequate regulations or market conditions). Most of the measures needed to address these issues are expected to be taken at the level of network codes and TCMs as well as at national level.

Develop LFMs

In the EU, LFMs have mostly been initiated as pilot projects. Given the lack of experience, EU MSs can use the existing balancing markets that have been functioning for a longer period of time as a model.

Therefore, some of the recommendations provided for the access of distributed flexibility resources to balancing markets could also apply to LFMs. This is especially true for access to the market of (aggregated) small producers and DR as well as TSO-DSO coordination. Improved TSO-DSO coordination rules could also be extended to DSO-DSO coordination when relevant (i.e., when a DSO uses the flexibility resources connected to the network of another DSO). Currently, there are no rules in EU law on such coordination. It may be an idea to at least amend the relevant network codes for this purpose.

LFMs organise the market-based procurement of flexibility services. To enhance legal certainty at EU level for the procurement of such flexibility services, we believe that the concept of “flexibility service” should be defined in the E-Directive. As an added benefit, any misunderstanding or confusion with the notion of ancillary services would thus be avoided.

In addition, national legislators and regulators should take a holistic view of procurement rules applicable to flexibility services and the deployment of LFMs. If authorities adopt a silo-based mindset, meaning that they assess reforms on an economic basis without integrating the overarching objective of decarbonisation, these reforms could actually delay the decarbonisation process, which is a fundamental target of EU energy policy. If the best economic and environmental solution is to develop market-based instruments and to level the playing field, this should be the way forward. Otherwise, other, possibly non-market-based schemes, such as administratively set prices, should be taken into account.

For LFMs to be widely used, harmonised operating rules are needed. If DSOs follow the example of balancing markets, they will operate LFMs themselves, just as TSOs do with balancing markets. However, this may raise questions regarding neutral market operation and would require an amendment to the unbundling regime. Another option would be to delegate the operation of the market to a third party, as is already applied in various pilot LFMs in Europe. In that case, the DSO would merely act as the sole buyer (although TSOs may also buy flexibility services on the same marketplace if the LFM rules would allow it). In addition, it would also be possible to create a so-called “common flexibility platform”, a cooperative rule-making body involving all relevant stakeholders.

We also note that balancing markets are increasingly being standardised in order to facilitate BSPs to offer balancing services across borders. It is very likely that LFMs will follow the same trend in order to increase the pool of flexibility resources and reduce procurement costs. Standardisation of flexibility products is already proposed in the 2019 E-Directive, it is a national energy policy goal in the UK and it is mentioned as a possibility in Danish Law. Some standardisation may indeed be profitable for all LFM actors, especially if new standards set reasonable thresholds for the supply of services by involving small and medium-sized resources, including through aggregation. Lessons can be learned, for instance, from a successful flexibility services tender run in the UK in 2017, where the minimum bid size was set at 100 kW, a level allowing distributed flexibility resources to participate. SMILE partner DTI also suggested proposing a generic national LFM setup and then adapting it to local contexts. Within the current EU legal framework, the EU DSO entity could establish guidelines or standards for the creation of LFMs and for the design of standard products. However, LFMs have a “local” component that will sometimes make it more difficult or counterproductive to apply such standards. Indeed, as SMILE partners and the literature have highlighted, some flexibility services are highly dependent on local conditions and cannot be supplied over long distances. Therefore, standardisation should be studied more closely, and it may be a good idea to introduce standardised products in terms of activation time, duration or minimum size when it is advantageous to do so, as in the case of TCMs for the balancing markets.

To facilitate the development of LFMs, legislators and regulators will also have to consider barriers created by external factors. Flexible connections are a good example of this. British DNOs use flexible connections to expand and accelerate the connection of vRESs in grid-constrained areas. Following the “last connected, first curtailed” principle, these new installations can suffer from a higher-than-expected level of curtailment, as happened in Orkney SMILE demonstrators. Flexible connections could therefore impede the development of more generation from vRESs, given the lack of financial security. In addition, flexible connections may disincentivise the use of LFMs as DNOs can simply curtail the installations without offering any compensation, instead of setting up an LFM to buy flexibility. In this case, legislators and regulators should control the use of flexible connections, adopting the aforementioned holistic view in this process.

Many of the abovementioned recommendations can be implemented by adopting new distribution network codes. Indeed, the existing network codes are mainly focused on TSOs, while DSOs have an increasingly important role to play in integrating more production from vRESs and facilitating the decarbonisation process. The legal basis already exists, as article 59 (1) of the 2019 E-Regulation allows for the adoption of network codes on voltage control, congestion management including services provided by active customers, citizen energy communities and the use of aggregation and DR, as well as the supply of non-frequency ancillary services and flexibility services to DSOs.

1 Introduction

The European Union aims to be climate neutral by 2050 [1]. To reach this target, Member States (MSs) must, inter alia, decarbonise electricity production. To do so, they are installing generation plants using renewable energy sources (RESs) on a large scale. The two main renewable energy technologies being installed are wind turbines and solar photovoltaic (PV) panels. One of the key characteristics of these technologies is that they depend on the intensity of the wind or the sunshine, which means that their electricity output is variable. The vast majority of these new installations is connected to the distribution network, given their installed capacity per site varies from a few kW (e.g., PV panels on a rooftop) to a few dozen MW (e.g., a wind farm). As a consequence, distribution networks (and transmission networks by extension) must be able to cope with this influx of production and its variability. This also has an impact on network balancing. The underlying question therefore concerns the organisation of the balancing of local grids.

Balancing refers to the actions taken to maintain equilibrium between electricity production and consumption at all times because without such equilibrium the network might collapse. Traditionally, balancing is done at national level and is managed by transmission system operators (TSOs) and a few large production or consumption sites. However, the continuous growth of variable renewable energy sources (vRESs) challenges balancing in two ways. Firstly, the closure of thermal plants and their replacement with vRES installations reduces the reserves that are available at any time to balance the electricity network. Secondly, the connection of more and more generation facilities to the distribution system may lead to the need for balancing at the local level rather than at the national level (on the transmission system). As a result, it became necessary to develop and use more flexibility resources to deal with disturbances closer to the source, meaning at distribution level. Flexibility can be understood as the modification of generation and/or consumption patterns in response to an external signal [2].

This deliverable analyses the legal framework applicable to network balancing and to the use of flexibility resources connected to the distribution network in the EU and in the SMILE demonstrator countries (Denmark, Portugal and the UK) in order to cope with the increase in generation from vRESs and to facilitate the decarbonisation process. This report is part of the SMILE H2020 project, which is testing and deploying various smart energy technologies on three European islands: Madeira (PT), Orkney (UK) and Samsø (DK). It also builds on the results of the SMILE deliverables D7.1 on the regulation of electricity storage, D7.2 on the integration of electricity and heat supply systems and D7.3 on the development of microgrids in the EU [3], but especially deliverables D7.1 and D7.3.

In terms of methodology, this deliverable is based on a study of relevant literature and legislation, supplemented with the results of a questionnaire sent to the SMILE partners on the use of flexibility resources on the SMILE islands and meetings for further clarification.

This deliverable starts by explaining what balancing is and discussing the challenges arising from the increase in variable generation from RESs. Subsequently, it analyses the EU legal regime governing balancing as well as three elements to address the increase of variable generation: (i) flexibility enablers (smart meters, energy storage, demand response and aggregation), (ii) TSO-DSO and DSO-DSO coordination, and (iii) procurement of flexibility services by DSOs. Next, it discusses the provisions applicable to these topics in three national legal frameworks and applies the results to the cases of the SMILE islands, following the same structure as in the previous chapter. The summaries at the end of each chapter condense the reasoning and results.

2 From national balancing to the use of local flexibility resources

The balancing of the electricity grid is traditionally done at national level, using large scale resources (thermal generation or hydropower) at the request of the company operating the grid. Since market liberalisation this will be the TSO. This is explained below in the first section of this chapter. However, the rise of distributed generation – which often involves several types of RESs – and flexibility resources challenges the idea of an electricity system being essentially balanced at TSO level. As a consequence, distribution system operators (DSOs) may have to be more involved in the dynamic operation of their networks. This is presented in the second section of this chapter.

2.1 What is electricity balancing?

An electricity grid must be balanced at all times, meaning that electricity production and consumption must be continuously equal. This equilibrium is measured through the frequency of the electricity being transported in the grid, which is set at 50 Hz in Europe. If the frequency increases or decreases too much, then a brown-out or black-out is looming [4].

Before the liberalisation process in the EU, it was “relatively easy to maintain the system balance”[5]. Vertically integrated electricity undertakings were in control of various or all of the activities of production, transport, distribution and supply of electricity and could easily plan for and maintain network frequency. However, with the liberalisation process and the separation between production and supply on the one hand and network operations on the other – unbundling – TSOs and DSOs do not have direct control over production nor information about planned consumption. Therefore, a mechanism is needed to ensure “the continuous adjustment of power generation and consumption [even in case of] forecasting errors (e. g. load and renewable generation) and technical disturbances (e. g. power plant outages)”[6]. This is the balancing mechanism. Balancing means that the TSO can intervene to ensure the equilibrium between production and consumption. When assessing the forecasts of the grid connected parties (producers and consumers) and the TSO finds that this may result in an imbalance, it may either request the producers to generate more (or less) in order to meet the consumption forecast or request consumers to reduce (or increase) the forecasted consumption. So far, the latter is usually only done by large industrial consumers who are in the position to do so but only if they are financially compensated. In addition, a TSO will need to intervene in case producers and consumers are not meeting the forecasts they have agreed on. If consumers are off taking more from the grid (or producers have injected less than forecasted), the TSO has to intervene. Such intervention could mean that the TSO needs to buy additional electricity for balancing purposes. As market liberalisation has developed, the balancing mechanism increasingly relies on market places being used by TSOs.

Chronologically, TSOs make use of the balancing market places after various electricity markets have been settled: year-ahead, month-ahead, day-ahead and intra-day markets [7]. Electricity markets organise the electricity exchanges, and shortly before delivery balancing markets are activated. As appears in figure 1, the balancing mechanism consists of several balancing markets where different types of frequency services are offered:

- frequency containment reserve (FCR), which is almost immediately activated after an imbalance in order to stop the frequency loss or excess and to stabilise it,
- automatic frequency restoration reserve (aFRR), which is an automated response to start re-establishing the optimal frequency level,
- manual frequency restoration reserve (mFRR), which is manually activated to finalise the return to the 50 Hz frequency, and

- replacement reserve (RR) is finally activated to avoid any new imbalance while assets providing the previous services are being replenished.

ENTSO-E explains the consecutive activation of these balancing services as follows [8].

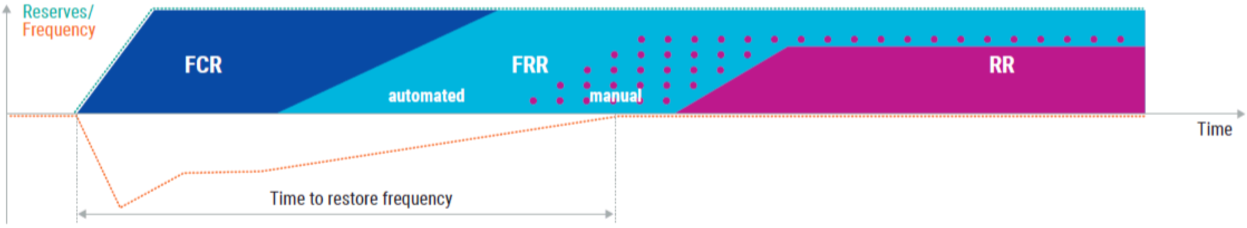

Figure 1 – Balancing markets [9]

The operation of each of these balancing markets is divided in three phases, as appears in figure 2 below: balancing capacity is offered and a share of it is selected, selected balancing capacity assets can be used to offer balancing energy bids that are activated if necessary and, finally, balancing costs are settled.

Balancing and the balancing markets involve three different actors: a system operator, a balance responsible party (BRP) and a balancing service provider (BSP). In the EU, the TSO operates the balancing market and is the single buyer of balancing capacity and energy [10]. As shown in figure 2 below, BSPs (e.g., generation or energy storage facility owners) offer their capacities on the balancing capacity market, indicating when their resources will be available and at what price. The TSO then selects the capacity it considers necessary. The BRPs (e.g., producers or suppliers) submit their schedule (expected electricity production and/or consumption) per unit of time on the day before delivery. Shortly before the time of delivery, and if the BRPs fail to stick to their schedule the TSO activates the necessary balancing energy bids as provided by BSPs – the previously selected bids on the balancing capacity market. This is the balancing energy market. Finally, BRPs pay for the costs incurred by the imbalance they caused to the system [11].

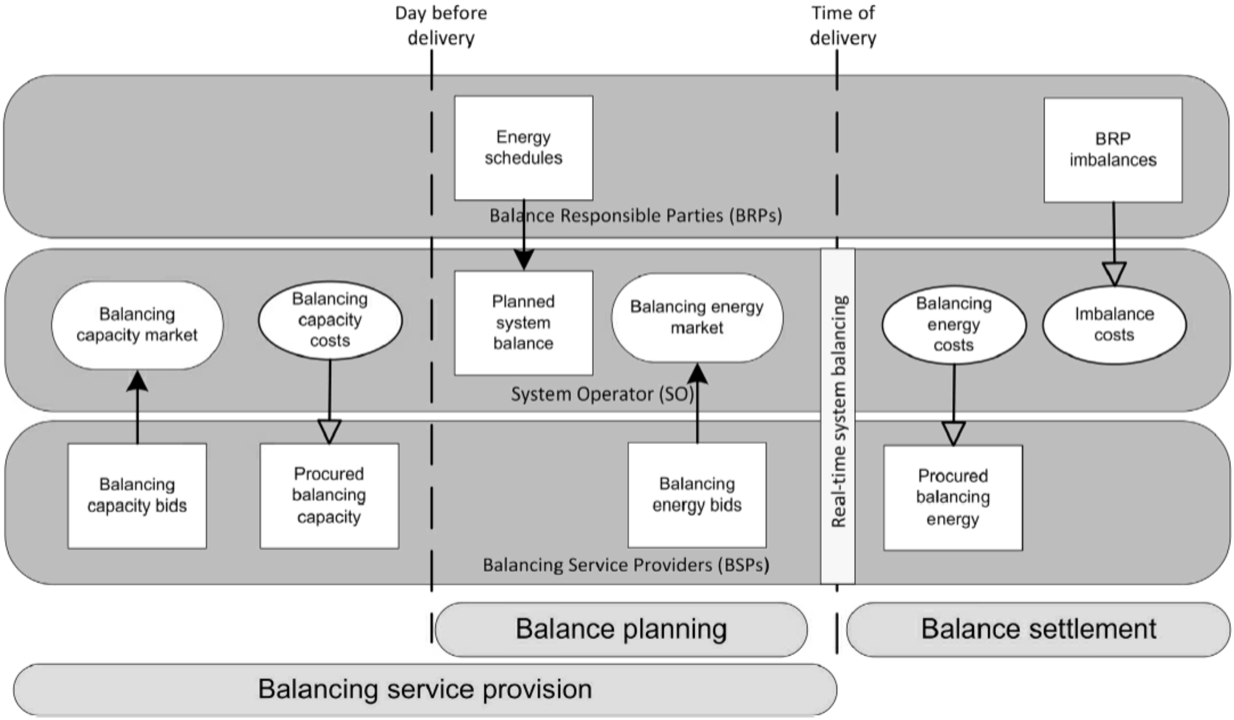

Figure 2 – Basic structure of a balancing market, ordered by time of occurrence (horizontal) and by actor (vertical) [12]

It should be noted that balancing markets are strongly influenced by the electricity sector of a Member State as a whole. This sector's size, energy mix, consumption characteristics, transmission and interconnection capacities as well as day-ahead and intra-day wholesale electricity markets all have a decisive impact on the balancing needs [13]. That is why,

> [a]lthough the same categories of [frequency] products exist in the EU, the exact product definition and the methodologies used for sizing or activation can still differ strongly from one control area to another. Also, the way balancing resources are procured in balancing markets and the exact working of imbalance settlement mechanism varies [14].

Despite these differences, European energy regulators have requested for years more harmonisation of the balancing markets and their rules [15]. Indeed, the possibility to share reserves and organise joint procurements should lower the balancing costs by using the best options in a larger pool [16]. In 2019, TSOs started implementing projects involving European balancing platforms for FCR, aFRR, mFRR and RR [17], as is detailed in section 3.1.4 below. Another means to lower the costs of balancing capacity is to expand technologies, sites and actors which can provide balancing services [18]. In particular, TSOs may benefit from using the balancing services offered by energy resources (production, consumption or storage) connected to the distribution grid [19]. However, the activation of a producer or consumer connected to the distribution grid by the TSO may create conflicts between the TSO and the relevant DSO and raises questions [20]. This is where the development of local flexibility markets becomes relevant, as will be discussed in the following section.

2.2 Dealing with the increase of variable distributed generation

The need for local flexibility markets

The increasing volume of electricity from vRESs being injected into the distribution network creates challenges for the balancing of the overall grid. Indeed, vRESs are more difficult to forecast due to their dependence on weather and they may end up congesting distribution networks that have been designed to convey electricity from the transportation grid to final customers, not the other way around. However, distribution networks also connect a growing number of flexibility resources, such as energy storage assets or (aggregated) smartened consumption providing demand response (DR). Energy storage allows for absorption of the excess production at a given time and feeding it into the grid at another, e.g. during peak demand. DR stands for a voluntary change in the consumption profile of a final customer, as a response to a signal such as an increase in price during a few hours. Aggregation refers to the bundling of various small to medium-sized flexibility resources. In addition, the ongoing installation of smart meters at all connection points allows DSOs to get a close-to-real-time picture of the generation, consumption and flexibility resources connected to its grid. This smartening of the network and growing flexibility available to DSOs presents an opportunity to support the overall balancing of the grid. Several of these technologies are being tested in the SMILE project. Yet, the activation of these flexibility resources must be organised. One of these solutions is to create local flexibility markets (LFMs).

Definition

LFMs are broader in scope than balancing markets as they can be designed for the use of different types of flexibility services (such as voltage regulation or local congestion management), but they are smaller in geographical terms. We note that definitions used in literature vary to some extent. According to Ramos *et al*., an LFM is a set of "long-or short-term trading actions for flexibility in a specific geographical location, voltage level, and system operator (DSO and TSO), given by grid conditions or balancing needs, where participants in a relevant market can be aggregated to provide flexibility services"[21]. Olivella-Rosell *et al*. essentially refer to "a trading platform for sharing information, exchanging flexibility and scheduling flexible devices"[22]. Jin, Wu and Jia consider LFMs as "an electricity flexibility trading platform to trade flexibility in geographically limited areas such as neighbourhoods, community, towns, and small cities"[23]. Buchmann focuses on local congestion markets that are defined in a similar manner: "markets through which distributed network users can provide flexibility to the (distribution) network operators to avoid network congestion"[24]. The element that keeps coming back is that LFMs are in essence trading platforms for flexibility services. They are a sort of small size balancing market. However, the flexibility services exchanged on these markets are voltage regulation and congestion management rather than frequency support [25]. Another difference from balancing markets is the element of LFMs' localness, which becomes visible through the criterion of limited geographical extension and sometimes by referring to distribution network users and operators. Therefore, as in SMILE deliverable D7.3 for microgrids [26], setting the boundaries of an LFM is an issue in and of itself. Last but not least, it should be noted that some LFMs already exist, mostly at the stage of pilots [27].

Actors

In terms of actors, LFMs build on the same principles as balancing markets, although with some nuances. As discussed in section 2.1, the actors operating on the balancing markets are system operators (TSOs), BRPs and BSPs. In case of LFMs, system operators are primarily DSOs as the relevant flexibility resources are connected to the distribution grid. The DSOs act as buyers on the LFMs and procure the flexibility services they need for the operation of their network [28]. Yet, TSOs can also buy flexibility services [29], although they will most likely not directly buy them from LFMs, but rather expect that local flexibility is aggregated on the LFM and then offered to the balancing markets. Please note that either DSOs or third parties can act as market operators [30], as in the case of traditional wholesale electricity markets (day ahead and intraday). BRPs in an LFM will buy the flexibility they need "to optimize their portfolio and realize their energy obligations"[31]. This means that DSOs may not act as the sole buyers on LFMs or that these markets consist of various components, one for DSOs, the other for BRPs. In any case, the equivalent of BSPs will sell the flexibility services. On LFMs, BSPs could be called flexibility service providers (FSPs). In fact, BRPs and FSPs can involve several different actors – such as producers, suppliers or large or aggregated customers – which can take both roles at the same time or alternatively. Indeed, Jin, Wu and Jia argue that "BRPs can be retailers, generators or aggregators"[32], which also holds true for FSPs. As specificity of LFMs and by contrast to balancing markets, aggregators are particularly important for the proper functioning of LFMs [33].

Organisation

The procedures governing LFMs are largely the same as for balancing markets [34]. It consists of a bid submission, an activation and a settlement phases. However, for LFMs to work smoothly, they need proper communication between their components. On the purely material side, Mercedes Vallés *et al*. state that "smart metering and information and communication technologies are essential enablers of DR"[35]. This data exchange layer is important at multiple levels. It is of special importance for the coordination between DSOs and TSOs in case they would like to use the same flexibility sources [36], as mentioned in section 2.1. But it also is important within the LFM. Indeed, LFMs can be organised as peer-to-peer or as peer-to-platform systems [37]. Peer-to-peer will typically require a lot of intelligent devices suitable to take decisions for each and every flexible asset. For peer-to-platform systems, it is easier to introduce aggregation and not all flexible assets have to be individually equipped to take decisions, only smart meters are needed in order to control the assets externally, therefore reducing the needed hardware and even more the communication and computational needs. This decentralised versus centralised debate is very similar to the one on the organisation of microgrids as detailed in

SMILE deliverable 7.3 [38]. As far as LFMs are concerned, Jin, Wu and Jia as well as Olivella-Rosell *et al*. favour centralised systems in order to avoid system overload [39].

Services

As mentioned earlier in this section, LFMs trade various flexibility services, but not frequency services, at least not directly. Indeed, according to the literature, LFMs are mostly used to trade flexibility services related to voltage control [40], local congestion management [41], controlled islanding [42], grid investments deferral [43] or electricity losses reduction [44]. These services are offered to the local DSO or DSOs according to their needs, especially as these have to integrate increasing quantities of electricity from vRESs. Several of these services are tested in the SMILE project, as will be discussed in chapter 4. In sum, LFMs are not balancing markets, but they organise the way in which various flexibility services are offered to local actors and, in addition, LFMs can be part of the process to aggregate local flexibility in order to offer frequency services on existing balancing markets operated by TSOs. They could be labelled indirect balancing markets, raising again the question of the coordination between TSOs and DSOs.

Legal issues

This characterisation of LFMs triggers various legal questions raised in the literature. As is often the case, these questions can be summarised in: Who is entitled to do what? Chapter 3 will attempt to provide answers to this overarching question. However, this deliverable cannot answer all of the literature's questions as these cover many different aspects. First, there is the crucial question of who should operate LFMs [45]. If DSOs are to operate these, the existing unbundling regime might have to be amended in order to guarantee that they will not discriminate against other actors [46]. Secondly, rules are needed to facilitate the coordination between TSOs and DSOs when activating distribution-grid connected flexibility resources. Who should have priority activation rights over these resources [47]? What if the activation by the TSO of a flexibility resource connected to the distribution grid causes an imbalance to the network [48]? Such coordination issues also arise between DSOs, "especially when DSOs start to use and organise flexibility markets for local congestion management"[49]. In this case, one can refer to DSO-DSO coordination [50]. The topic of locational prices (reflecting the local state of the network through a price) is linked to these coordination unknowns too [51]. Third, there are other legal questions, raised in some articles but still relevant. There is the issue of contracts: for instance, in an LFM organised by an aggregator all participants need to have a contract with this operator [52]. How to organise this? There is the issue of the digital infrastructure: its ownership and operation as well as the legal mandate to deploy smart meters [53]. Who can do so? Finally, the measures for protection and empowerment of consumers will also appear at some point [54].

2.3 Summary

Electricity grids must always be balanced, meaning that production and consumption must be equal at all times. In the EU, this is done through national balancing markets operated by TSOs. The TSOs buy balancing services from BSPs when BRPs fail to meet their production or consumption schedules. Currently, balancing markets are in the process of being merged into European platforms in order to create a unified balancing market for each product category (FCR, aFRR, mFRR and RR) and to reduce balancing costs.

In order to accommodate more electricity from vRESs in the electricity system and tap into the growing pool of local flexibility resources connected to the distribution grid consisting of generation, storage and (aggregated) DR services, a possible solution is to create local flexibility markets. According to the literature, LFMs are essentially trading platforms for flexibility services. LFMs function as balancing markets, but they are used for the exchange of flexibility services other than frequency, and they have a limited geographical scope. In term of actors, the two most important ones are DSOs and FSPs. In a nutshell, DSOs can use LFMs to buy flexibility services from FSPs.

3 From balancing markets to the use of local flexibility resources in EU law

Grid balancing is essential for the proper functioning of the electricity system and has become more complex since market liberalisation as it requires detailed arrangements between market parties (electricity producers and consumers) and the TSO. The first Electricity Directives, however, barely refer to balancing. It seems that balancing was thus considered an issue that should be dealt with by national law. Yet, over the past few years, a quite detailed set of rules has emerged on EU level to harmonise the different balancing market rules across the Union. In parallel, the term "flexibility" was used in the 2019 E-Directive and E-Regulation for the first time. Flexibility is the ability to increase or decrease electricity generation or consumption as requested by flexibility service buyers, including system operators, and is broader in scope than balancing. The first part of this chapter describes the EU regime for balancing as included in the 2019 E-Directive and E-Regulation as well as in network codes. The second part of this chapter assesses legal instruments governing the use of flexibility resources by DSOs to facilitate the increase of RES facilities connected to the distribution grids and thus affecting the entire electricity system.

3.1 Balancing rules in the EU

This section builds on the previous section 2.1 and describes the legal regime applicable to balancing markets in the EU. It starts by providing the legal definition of balancing and balancing markets before outlining the principles, actors and services relevant for these markets. In addition, it presents the legal basis for the establishment of European balancing platforms.

Balancing rules are not only part of the 2019 E-Directive and E-Regulation, but are also included in several network codes. Network codes were presented in general and some of them in more detail in deliverable D7.3 of the SMILE project [55]. In a nutshell, there are eight network codes, which have been adopted as EU regulations and therefore directly applicable in EU MSs. When it comes to balancing, the most important network code is the guideline on electricity balancing (EB GL)[56]. This regulation "establishes an EU-wide set of technical, operational and market rules to govern the functioning of electricity balancing markets"[57]. The EB GL is supplemented with the electricity transmission system operation guideline (SO GL)[58]. Although network codes apply primarily to TSOs, they sometimes also refer to DSOs. The latter will be discussed further below in section 3.2.2 about TSO-DSO cooperation, but in essence, the network codes consider DSOs as actors in the balancing markets and without their cooperation and their data, the system simply cannot work properly.

3.1.1 Definitions

The 2019 E-Directive defines electricity markets as "markets for electricity", including "markets for the trading of energy, capacity, balancing and ancillary services in all timeframes"[59]. Hence, when rules apply to electricity markets in general, they also apply to balancing markets and to any potential local ancillary services market used by DSOs, as is will be discussed further below in section 3.2. It is striking, however, that the 2019 E-Directive does not define balancing. Instead, it refers to the 2019 E-Regulation [60], which defines balancing as:

> all actions and processes, in all timelines, through which transmission system operators ensure, in an ongoing manner, maintenance of the system frequency within a predefined stability range and compliance with the amount of reserves needed with respect to the required quality [61].

This definition confirms that TSOs are responsible for the balancing markets. The 2019 E-Regulation also defines both other actors in the balancing market: BRPs and BSPs [62]. These actors and the services they can provide will be discussed in section 3.1.3 below.

3.1.2 Principles

Article 3 of the 2019 E-Regulation lists a set of principles regarding the operation of the electricity markets (and thus also the balancing markets). It applies to MSs, national regulatory authorities (NRAs), TSOs, DSOs and market operators. The list of principles is quite long but it basically consists of two main categories: organisation and goal. As regards "organisation" the rules are quite straightforward and essentially state that electricity markets rely on demand and supply and that all interested market participants should be able to access these markets. The goal setting rules are more diverse but it seems that the most important rule is that: "market rules shall enable the decarbonisation of the electricity system and thus the economy"[63]. All other principles, such as ensuring access to final customers through aggregation, fostering investments into infrastructures or enabling efficient dispatch directly or indirectly concur to this final aim. Therefore, both the existing balancing markets and all the existing and future ancillary markets, including the ones being used by DSOs, have to comply with this principle.

When it comes to balancing markets *per se*, article 6 of the E-Regulation issues the main rules. In essence, this article applies the general market principles from article 3 to the balancing markets. It states inter alia that market participants shall be treated in a non-discriminatory manner, whilst taking into account the technical needs of the electricity system and the technical capabilities of the different technologies used to provide the services [64]. Therefore, the balancing market also has to adapt to these technologies – including the new flexibility resources. In addition, the article provides that balancing services are defined in a transparent and technologically neutral manner and are procured in a transparent, market-based manner [65].

The EB GL also contains a list of principles that apply to balancing markets and that are very similar to the ones in the E-Regulation. Whereas the organisational principles refer to the need for effective competition and enhanced efficiency, the goal setting principles focus on facilitating the participation of DR, aggregation and energy storage as well as RESs [66].

In brief, according to EU law, balancing markets have to serve the overarching principle of decarbonising the economy and they have to do so through transparent, non-discriminatory and market-based instruments.

3.1.3 Actors and services

As mentioned in section 2.1, the three actors taking part to balancing markets are TSOs, BRPs and BSPs. In particular, BSPs provide frequency services to TSOs in order to maintain or restore the stable frequency level when BRPs fail to stick to their schedules.

Actors

According to the 2019 E-Directive, the main task of the TSOs is to ensure the long-term ability of the system to meet reasonable demands for the transmission of electricity [67]. Consequently, when BRPs fail to stick to their production or consumption schedules and endanger the network's stability, TSOs have to procure ancillary services from third parties to ensure operational security [68]. As a part of this process, TSOs have to procure balancing services in a transparent, non-discriminatory and market-based manner [69]. In addition, the directive requires that the participation of all balancing market parties should be possible, including of BSPs offering energy from RESs, engaged in DR, in aggregation or operating energy storage facilities [70]. In order to enable such participation of all interested markets parties, TSOs and NRAs must establish technical requirements for participation in balancing markets, on the basis of the technical characteristics of those markets and in close cooperation with all market participants [71]. In sum, (i) TSOs have to use balancing markets to select the services they will activate in order to keep the grid running, (ii) all market participants can offer services to these markets – with a focus on the providers using RESs, DR, aggregation or storage – and (iii) market participants must be involved in the elaboration of the participation rules. Therefore, the more small and medium-sized DR and aggregation providers will be willing to participate in the balancing markets, the more they may advocate for adequate rules, facilitating the use of distribution-grid connected flexibility resources for offering balancing services.

The 2019 E-Regulation defines BRPs and BSPs as well as balancing capacity and energy. According to article 2 (14), a BRP (or its chosen representative) is a market participant responsible for imbalances in the electricity market. Article 5 (1) of the regulation specifies that all market participants are BRPs and thus responsible for their imbalances, except if they delegate this responsibility. A classic, small-size final customer automatically sees his responsibility shifted to his electricity supplier. Small-size final customers can become BRPs if they become active customers [72]. This is also specified for energy communities [73] and for actors providing DR through aggregation [74]. Yet, in the case of generators using RESs with an installed capacity of less than 400 kW, MSs can decide to automatically transfer the balance responsibility to another market participant [75]. The use of this option by EU MSs facilitates the involvement of small RES producers into the balancing market. This is also a rule that should be used in any other flexibility market and especially in an LFM in order to facilitate the participation of (aggregated) small providers.

According to article 2 (12) of the 2019 E-Regulation, a BSP is a market participant providing either or both balancing capacity and balancing energy to TSOs. Balancing capacity is defined as “a volume of capacity that a [BSP] has agreed to hold and in respect to which the [BSP] has agreed to submit bids for a corresponding volume of balancing energy to the [TSO] for the duration of the contract”[76]. Balancing energy refers to the energy used by the TSO to carry out balancing [77].

The relevant network codes provide a higher level of detail on how balancing markets work and contain some further definitions. The EB GL explains that the BSP uses reserve-providing units or groups to offer balancing services after a prequalification process to validate the quality of its products [78]. The terms of “reserve provider” (an equivalent to BSP), “reserve providing unit” and “reserve providing group” are not defined in the EB GL but in the SO GL. According to this latter guideline, a reserve provider is a legal entity with a legal or contractual obligation to supply frequency services from its units or groups [79]. A reserve providing unit is a single or an aggregation of power-generating modules (PGMs) and/or demand units connected to a common connection point fulfilling the requirements to provide frequency services [80]. And a reserve providing group is an aggregation of PGMs, demand units or reserve-providing units connected to more than one connection point [81]. All these definitions are therefore exclusively used for the frequency market. The two last definitions (reserve providing unit and group) are built upon PGMs and demand units. PGMs and their categories – ascendingly ranked from type A to type D based on their installed capacity and voltage connection level – are provided for in the network code on requirements for grid connection of generators (RfG NC) and are extensively described in SMILE deliverable D7.3 [82]. In essence, they are electricity generating assets. When PGMs are grouped, they are labelled power-generating facilities (PGFs)[83]. Demand units are defined in yet another network code: the network code on demand connection (DC NC). It defines a demand unit as “an indivisible set of installations containing equipment which can be actively controlled by a demand facility owner […], either individually or commonly as part of demand aggregation through a third party"[84]. In a nutshell, a BSP is an actor controlling one or multiple production or demand assets it uses to provide frequency services.

Services

The frequency services mentioned hereinabove are defined in the SO GL. They correspond to the services used in figure 1 of section 2.1: FCR, aFRR, mFRR and RR. FCR refers to products aimed at containing the frequency within acceptable limits after an imbalance [85], the aFRR and mFRR intervene to restore the normal frequency level [86] and the RR stands for products supporting the restoration of the normal frequency level, for a longer period of time than FRR and to shield the network against new imbalances that would incur in the meantime [87]. The exact expected characteristics of these products are also provided by (part IV of) the SO GL. It appears that most rules regarding products are included in the SO GL and not in the EB GL. However, article 25 of the EB GL sets requirements for standard balancing products to be developed jointly by TSOs and NRAs and included in a number of terms and conditions or methodologies of implementation (TCMs). This standardisation rule applies to aFRR, mFRR and RR, so that BSPs can submit their bids according to harmonised rules at a regional scale, allowing TSOs to tap from a larger pool of competitive frequency services. These TCMs will apply from end of 2021 and they will set products' standards relating to the validity, delivery and activation time requirements of the bids as well as to the minimum bid size which is usually set at 1 MW, representing a barrier for small and medium-size flexibility providers [88].

Article 6 (9) of the 2019 E-Regulation also provides a very specific rule for the procurement of frequency services by TSOs. It reads as follows:

> The procurement of upward balancing capacity and downward balancing capacity shall be carried out separately, unless the regulatory authority approves a derogation from this principle on the basis that this would result in higher economic efficiency as demonstrated by an evaluation performed by the transmission system operator.

Upward balancing means increasing electricity injection into the grid or reducing offtake and downward balancing logically stands for the opposite. If upward and downward balancing capacities are procured together, it means that the BSP must be able to both increase and diminish its electricity injection into the grid as requested. This typically requires a generator that can easily ramp up or down production or a consumer that easily can interrupt consumption. Traditionally, hydropower is a natural best-fit to provide upward and downward balancing thanks to its capacity to quickly ramp up or down its production. By contrast, other RESs being harvested by wind turbines and PV panels are not as flexible as they must use the energy when it is available at its maximum. Every voluntary reduction of production is a loss, while as a general rule the water in a reservoir that is not used at time T can be used at T+1. As a consequence, if upward and downward balancing are procured separately, a wind farm operator can, with the help of forecasting tools, propose a certain amount of supplementary production it is almost certain to be able to offer without having to provide the downward capacity too, or vice-versa. This separate procurement rule also favours the development of energy storage as for instance a battery can be emptied by providing upward balancing and can be filled up when more profitable and on the market of its choice. This allows benefit-stacking, as storage operators can stack the benefits from different types of services they offer on different markets. An example is provided in section 4.1.2.2 about the UK where the effects of this rule have been highlighted.

3.1.4 European balancing platforms

As mentioned in section 2.1, TSOs started implementing projects for European balancing platforms in 2019. This is the result of articles 19 to 21 of the EB GL, requesting TSOs to create European balancing platforms in order to facilitate the transboundary exchange of aFRR, mFRR and RR products. In addition, article 22 requires the creation of a fourth platform to exchange balancing energy from imbalance netting while a fifth platform for the exchange of FCR products is being voluntarily implemented by 10 TSOs in seven EU countries, including a SMILE country: Denmark [89]. Therefore, balancing markets are increasingly becoming European, significantly increasing the potential market for BSPs and the pool of frequency services available to TSOs. However, this evolution might be detrimental to the local provision of frequency services offered by small and medium installations, even aggregated. At least if there is no mechanism such as a locational pricing to give a value to locally-available flexibility resources.

3.2 Dealing with the increase of variable generation from RESs

The 2018 RES-Directive stipulates that EU MSs shall collectively ensure that a share of 32% of the Union's gross final energy consumption comes from renewable sources by 2030 [90]. This target will be increased to 38%-40% by 2030 in order to meet the target of 55% of greenhouse gases emissions reductions by the same year and to stay in line with carbon neutrality by 2050 [91]. Although large scale electricity production from RESs (such as offshore wind parks) will be connected to the transmission network, important parts will also be developed locally and connected to the distribution grid. Small-size distributed generation from RESs will, for example, be instrumental to fulfil the RES target. The variability and at times massive influx of electricity from RESs poses a challenge to the smooth operation of distribution networks, as highlighted above in section 2.2. However, at the same time households could provide flexibility through the use of electric vehicles [EVs], batteries or by smartening their consumption [92], and thus providing opportunities for facilitating the growing injection of energy from vRESs into the distribution network.

This section will first discuss the legal framework applicable to four technologies and activities that could facilitate the increase in RES generation: smart meters, energy storage, demand response and aggregation. They provide flexibility resources connected to the distribution network and can be used by the DSO to cope with variable generation. Thereafter, this section analyses the provisions in the 2019 E-Directive and E-Regulation focussing on the coordination of TSOs and DSOs and allowing for using flexibility instruments to provide balancing services. Finally, this section identifies the EU law provisions requiring DSOs to procure the flexibility they need for operating their grid, often in a market-based manner. These last provisions may facilitate the rapid spread of LFMs in the EU.

3.2.1 Regulating enablers: smart meters, energy storage, demand response and aggregation

Below we will discuss the above-mentioned four technologies and activities that will play a key role in meeting the RES targets and at the same time maintain the operation of the grid.

Smart meters

Smart meters enable various actors of the electricity chain getting information about production and consumption at each grid connection point. They help the final consumer which can also be a small producer to be aware of its consumption/production patterns, they allow suppliers (often the consumer's BRP) to schedule the planned consumption more accurately and they provide the DSO with a better overview of the production and demand and to detect grid faults. TSOs also have an interest in being forwarded the aggregated data from smart meters. As mentioned in section 2.2, smart metering is an essential enabler of DR. This is especially true in the case of aggregated DR. Indeed, to offer flexibility services of a reasonable size, aggregators can mobilise a large pool of small-sized flexibility resources and each needs to be equipped with a smart meter. Since 2006, a growing body of legal provisions on the deployment of smart meters in the EU has been adopted [93].

In the 2009 E-Directive, a target for the deployment of smart meters was set to EU MSs. They had to conduct by September 2012 a cost-benefit assessment of the deployment of "intelligent metering systems" in their countries. If positive, then at least 80% of the consumers had to be equipped with a smart meter by 2020 [94]. Despite this target, a 2020 report for the European Commission has shown that as of 2018, only "34% of all electricity metering points were equipped with a smart meter" in the EU-28 [95]. The authors estimate that the threshold of 80% of the connected customers equipped with a smart meter in the EU will not be reached before 2024 at least, possibly later [96]. This report as well as another more recent report show that the level of deployment varies strongly between countries, with some having reached 100% long ago and others only starting [97]. Such difference in deployment should be overcome as smart meters are an important means to facilitate the energy transition at the least possible cost, it is therefore crucial to follow up on the rapid deployment of smart meters that are compatible with the access rules of the flexibility markets.

The 2019 E-Directive maintains a focus on smart meters, although the relevant provision was slightly altered [98]. Moreover, the 2019 E-Directive now also regulates the deployment of smart meters [99]. First, the directive defines a "smart metering system" as:

> an electronic system that is capable of measuring electricity fed into the grid or electricity consumed from the grid, providing more information than a conventional meter, and that is capable of transmitting and receiving data for information, monitoring and control purposes, using a form of electronic communication [100].

A smart meter therefore enables parties to monitor the production/consumption of an installation situated at another location, but also potentially to remotely control it. Secondly, the 2019 E-Directive specifies that in case of a negative cost-benefit analysis, it has to be repeated at least every four years [101]. In the meantime, final customers are entitled to request the installation of a smart meter whilst bearing the associated costs [102]. Thirdly, the installed smart meters have to comply with a few technical requirements. These requirements include access to the data by the final customer, privacy issues and so on [103]. Yet, there is one point that is especially relevant to the provision of flexibility services. Article 20 (1) (g) states that smart meters "shall enable final customers to be metered and settled at the same time resolution as the imbalance settlement period in the national market." This imbalance settlement period is harmonised at EU level by article 53 (1) of the EB GL [104]. According to this article, TSOs had until end of 2020 to apply an imbalance settlement period of 15 minutes. TSOs could request a derogation to their NRAs but if granted it will be reassessed at least every three years [105].

This alignment of metering on the imbalance settlement period is key. This is a condition for flexibility resources to provide services on the balancing and other flexibility markets. Therefore, it underlines the link between smart meters and smart grids. This is why authors refer to smart meters as enablers for accessing DR schemes [106], why the E-Directive insists on the interoperability between smart meters and smart grids [107], why the 2019 E-Regulation entrusts the new EU DSO entity to contribute to the deployment of both smart grids and smart meters as parts of the same provision [108] and why the SMILE partners insisted that solely deploying smart meters is not enough, smart meters with at least half-hourly settlement (in a UK context) are needed if the metered installations are to offer balancing (and other flexibility) services.

The gradual rollout of the smart meters in the entire EU will bring at least two consequences of interest for this study. On the one hand, as Buchmann wrote, DSOs will become “owners and operators of a digital infrastructure as well”[109]. This means that they will harvest the data from the metered flexibility resources connected to their network. This raises the question of the sharing of this data with other actors, including with TSOs and other DSOs that may be interested in accessing these resources. The topic of TSO-DSO and DSO-DSO coordination is dealt with further below in section 3.2.2. On the other hand, the 2019 E-Directive provides that final customers who have a smart meter can “request to conclude a dynamic electricity price contract with at least one supplier”[110]. When 80% of the connected customers will have a smart meter, 80% of the connected customers will be in capacity to request such a contract, facilitating DR. In this case though, dynamic electricity price contracts especially facilitate implicit DR (consumers make short-term changes in their energy demand, as a reaction to time-varying electricity prices), while DSOs may be more interested in explicit DR (consumers or aggregators propose flexibility resources on the relevant markets) for the management of their network [111].

Energy storage

Energy storage is becoming of increasing importance to balancing markets and will be decisive for the development of LFMs. Indeed, storage technologies will enable to quickly react to dropping frequency or voltage and are essential to maintain the equilibrium of a network and preserve its assets. Storage can also solve congestion issues and avoid curtailments by charging from the grid when there is excess electricity production and injecting it into the grid when cables are back to normal situation. SMILE deliverable D7.1 has already provided an in-depth analysis of the new legal regime adopted at EU level for the deployment of energy storage technologies. In essence, energy storage is now defined in article 2 (57) of the 2019 E-Directive. Articles 36 and 54 respectively prohibit DSOs and TSOs from owning and operating storage assets, except for a limited list of exemptions. Therefore, energy storage is considered as a market activity, to be owned and operated by other actors than network operators. Energy storage can be applied by several market parties, including small ones (i.e., active customers and citizen energy communities [112]), and provide a variety of services, such as flexibility services to DSOs or ancillary services (including balancing) to TSOs [113].

Demand Response

Traditionally, DR is provided by large consumers, also under the name of interruptible load. DR is defined by article 2 (20) of the 2019 E-Directive as “the change of electricity load by final customers from their normal or current consumption patterns in response to market signals, […] or in response to the acceptance of the final customer's bid to sell demand reduction or increase at a price in an organised market […]”. This definition corresponds to the notions of implicit and explicit DR mentioned two paragraphs above. The directive essentially aims at ensuring that any actor – including final customers through aggregation [114]– that is willing to provide services through DR can do so by accessing the relevant electricity markets [115]. In addition, it states that the procurement of various flexibility services such as balancing and non-frequency ancillary services by both DSOs and TSOs must allow for the participation of actors using DR [116]. It also requires DSOs and TSOs to take into account DR in their respective network development plans [117]. The 2019 E-Regulation follows the same logic of full integration of DR activities into all electricity markets [118], including into the balancing mechanism [119].

Aggregation

The 2019 E-Directive defines an “independent aggregator” as “a market participant engaged in aggregation who is not affiliated to the customer's supplier”[120]. We can therefore deduce that an aggregator is either the customer’s supplier or an independent aggregator. In addition, the directive defines “aggregation” as “a function performed by a natural or legal person who combines multiple customer loads or generated electricity for sale, purchase or auction in any electricity market”[121]. The activity’s definition contains the idea that aggregated products can be offered on any electricity market.

As shown in section 3.1.1, electricity markets are broadly understood in the 2019 E-Directive as markets that cover wholesale electricity markets as well as balancing or other ancillary services markets. Pursuant to the directive, market participants engaged in aggregation also have the right to access electricity markets “without the consent of other market participants”[122]. Similar to DR, DSOs and TSOs must allow for the participation of actors engaged in aggregation into their flexibility markets [123]. In order to ensure that final customers can engage into aggregation and therefore facilitate the assembling of large aggregation volumes to be offered as services on balancing or other flexibility markets, the directive creates the right to an aggregation contract [124]. As a result, customers are free to undertake such activity without the consent of their supplier. However, these freedoms and rights have a consequence: market participants engaging in aggregation are financially responsible for the imbalances they cause in the system [125]. In other words, final customers become BRPs in this case, as mentioned in section 3.1.3. However, they can delegate this responsibility to another BRP, potentially to the independent aggregator. The 2019 E-Regulation only confirms the logic of the directive in providing for full access of market participants using aggregation to all electricity markets [126], including the balancing market [127].

3.2.2 TSO-DSO and DSO-DSO coordination

The process of integrating more distributed RES generation and flexibility resources into the system raises many questions. One of them is who should have priority in using these resources that can serve as means to provide balancing or other flexibility services: the connecting DSO or the TSO? Another question in this case would be: “how real-time TSO-DSO coordination should be done”[128]. In addition, questions about DSO-DSO cooperation are emerging with the rise of distributed production and flexibility resources, potentially creating but also able to solve voltage or congestion management issues for various DSOs.

The topic of TSO-DSO coordination (also sometimes referred to as TSO-DSO cooperation) is already part of the EU legal framework. According to the 2019 E-Directive, both TSOs and DSOs have to involve each other when setting the rules for the procurement of flexibility services by DSOs [129] and of non-frequency ancillary services by TSOs [130]. More directly relevant to the balancing mechanism, DSOs are obliged to cooperate with TSOs for the effective participation of balancing markets participants connected to the distribution grid [131]. We are here at the heart of the question of the use of distribution-grid connected flexibility resources by TSOs, but the provision does not indicate a priority rule (i.e., whether the TSO or the DSO has priority to use a flexibility resource connected to the distribution grid when this resource can provide services to both grid operators). It only instructs DSOs to cooperate and refers to article 182 of the SO GL, analysed in the next paragraph below.

The 2019 E-Regulation also adopts a mutual obligation of cooperation between TSOs and DSOs. First, it does so through the EU bodies aiming at the cooperation of TSOs and DSOs: ENTSO-E and the EU DSO entity. Each institution has to cooperate with the other and they can issue some rules together, for instance in the case of future network codes [132]. Secondly, the regulation contains an article dedicated to the cooperation between DSOs and TSOs. This provision requires DSOs and TSOs to cooperate with each other in planning and operating their network [133] and to achieve coordinated access to distributed generation, storage or DR resources [134]. Therefore, in the regulation as in the directive, DSOs and TSOs have to cooperate, including for access to distribution-grid connected flexibility resources but they are not subject to any priority access rule. These provisions shall facilitate the functioning of both balancing markets and potential LFMs, as they allow more exchange of data between DSOs and TSOs.

The relevant network codes, presented above in section 3.1, contain more detailed rules about cooperation between TSOs and DSOs and access to distributed resources. To start with, article 15 of the EB GL is entitled "Cooperation with DSOs". This provision states that DSOs, TSOs, BSPs and BRPs "shall cooperate in order to ensure efficient and effective balancing"[135]. The article also requires DSOs to "provide, in due time, all necessary information in order to perform the imbalance settlement to the connecting TSO"[136]. These provisions clearly underline that DSOs are to be considered as actors of the balancing markets. Their cooperation and their data are needed for the system to run properly. Moreover, article 15 (3) of the EB GL also refers to another interesting role of DSOs: reserve connecting DSOs. The SO GL defines in article 2 (149) the reserve-connecting DSO as the "DSO responsible for the distribution network to which a reserve providing unit or reserve providing group, providing reserves to a TSO, is connected". According to article 182 of the SO GL, this DSO has to be involved in the prequalification process for the reserve units or groups and may set limits to the activation of reserves located in its distribution system, therefore acquiring a sort of veto right [137]. In addition, part II, title II, chapters 3 and 5 of the SO GL set the rules for the exchange of data between TSOs and DSOs, essentially requiring from DSOs to provide the relevant data they have access to (with regard to distribution grid-connected facilities) to their TSO. These network codes thus show that in order for TSOs and DSOs to cooperate in the balancing markets (and potentially for LFMs), DSOs need to provide data to TSOs. TSOs do not have the same kind of obligation towards DSOs. Moreover, it seems that the SO GL gives priority to TSOs to activate flexibility resources for balancing markets, although with a veto right for reserve-connecting DSOs.

It appears from a 2021 report on DSOs that the implementation of the aforementioned obligation that DSOs and TSOs share data is applied in different manners in EU MSs [138]. Indeed, data sharing about demand and generation forecasts, schedules of PGFs as well as real-time and ex-post measurements varies a lot, with some DSOs sharing it on a 15 minutes basis while others do it daily, weekly, monthly or apparently not at all. Data exchange on network conditions between TSOs to DSOs also allows the latter "to guarantee the security of supply to its customers and prepare for planned disruptions coming from the transmission side"[139]. In all these cases, data exchange should be generalised and brought to the smaller possible timeframe – if possible 15 minutes – if TSOs and DSOs are to use the opportunities of distributed variable RES production and flexibility resources.

In comparison to all the above on TSO-DSO coordination, DSO-DSO is not an issue dealt with in EU law, apart maybe from the provisions on the EU DSO entity requiring DSOs to cooperate at Union level through this new body [140]. Within the current framework, the EU DSO entity could serve to establish guidelines or standards for the creation of local flexibility markets and for the design of standard products, if deemed useful.

3.2.3 Flexibility services procurement by DSOs

Recital 10 of the 2019 E-Directive links the term "flexibility" to the necessary adaption of the electricity system to cope with the rise of variable and distributed generation from RESs. Yet, although mentioned in the 2019 E-Directive, flexibility services are not defined there. According to Papsch, this was deliberately done by EU legislators in order "to give national authorities a degree of discretion in how to implement this relatively new concept in the field"[141]. However, the use of both the terms "flexibility services" and "ancillary services" in the directive may result in overlapping situations.

Ancillary services are defined in the 2019 E-Directive as services "necessary for the operation of a transmission or distribution system, including balancing and non-frequency ancillary services, but not including congestion management"[142]. Non-frequency ancillary services is thus a sub-category of ancillary services and is defined as "a service used by a [TSO] or [DSO] for steady state voltage control, fast reactive current injections, inertia for local grid stability, short-circuit current, black start capability and island operation capability"[143]. Flexibility services, however, constitute a broader category of services that system operators can use to manage their networks. Article 32 (1) of the directive provides that flexibility services used by DSOs include congestion management, which is excluded from ancillary services as mentioned above. According to the same provision, DSOs can also use flexibility services to "improve efficiencies in the […] development of the distribution system". This can be offered through a specific service called "grid investment deferral" that enables a third-party to take some measures – e.g., install a battery – against a fee as a result of which the DSO does not have to invest in new hardware. It reduces congestion and avoids that the DSO has to invest in a new power line. This service as well as other services mentioned in section 2.2 above (voltage control, local congestion management, controlled islanding and electricity losses reduction) can be traded on potential LFMs. In this same section voltage control, local congestion management, controlled islanding and electricity losses reduction were also mentioned. In terms of legal classification, voltage control and controlled islanding are part of the non-frequency ancillary services and congestion management is not an ancillary service but falls under the flexibility services. Moreover, the reduction of electricity losses is tailored to fulfil the obligation for DSOs to cover energy losses as provided under article 31 (5) of the directive and will be discussed in the next paragraph. As these services that can be exchanged on LFMs may be subject to different qualifications, they may also face different legal regimes. To facilitate the understanding, figure 3 below summarises the interpretation of flexibility services according to the 2019 E-Directive.

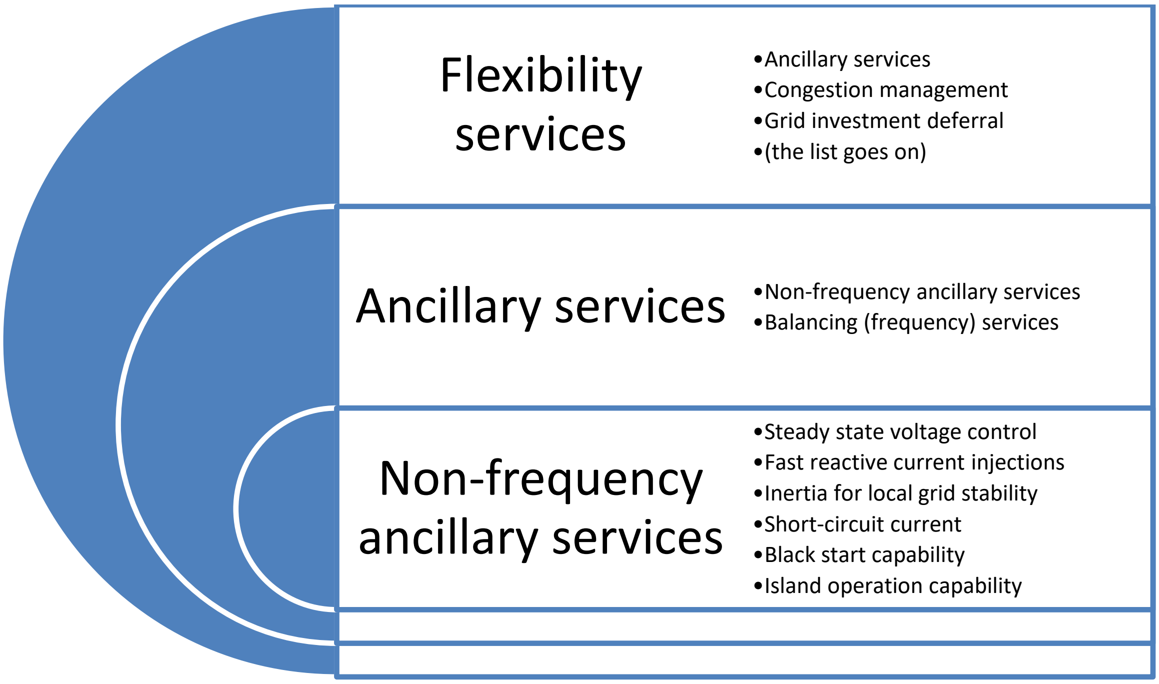

Figure 3: Flexibility and ancillary services according to the 2019 E-Directive.

So far, DSOs do not have organised markets to buy flexibility services such as local congestion management [144]. Even non-frequency ancillary services, although more visible in the legal framework than flexibility services, "are not subject to a detailed framework" in EU law [145]. However, this is changing. First, the 2019 E-Directive requires DSOs to act as neutral market facilitators when they procure the energy they need to cover their energy losses – resulting from transportation and conversion of electricity via their cables and substations [146]. This has to be done "in accordance with transparent, non-discriminatory and market-based procedures". Secondly, the procurement of non-frequency ancillary services by DSOs has to follow "transparent, non-discriminatory and market-based procedures"[147]. Thirdly, "[w]here a DSO is responsible for the procurement of products and services necessary for the efficient, reliable and secure operation of the distribution system, rules adopted by the DSO for that purpose shall be objective, transparent and non-discriminatory […]"[148]. It is important to note that these rules apply only if and when DSOs are responsible for the procurement of the aforementioned services. Fourthly, MSs "shall provide the necessary regulatory framework to allow and provide incentives to [DSOs] to procure flexibility services"[149]. Therefore, DSOs are not obliged to procure flexibility services. As Jones and Kettlewell argue, DSOs can still provide flexibility by themselves instead of procuring it to third parties [150]. Yet, if they procure it, they have to do so "in accordance with transparent, non-discriminatory and market-based procedures"[151]. In sum, DSOs have to create markets for the procurement of energy to cover their losses, of non-frequency ancillary services and of flexibility services if they want to procure them at all. This is very likely to fast-track the development of LFMs in the EU in the coming years.

The above rules are subject to a few exemptions. The first ones are actor-based exemption schemes, relieving DSOs from some of their duties in specific circumstances (such as for isolated systems). They have been analysed in SMILE deliverables D7.1 and D7.3 [152]. The second type of exemptions are activity-based. This is how an NRA can exempt a DSO from procuring the non-frequency ancillary services in a market-based manner [153]. The NRA has to assess whether it is economically efficient to create such a market. If not, an exemption can be granted. The same rule applies to the market-based procurement of flexibility services, yet with a broader ground for exemption. An NRA can provide a derogation after an assessment shows that market-based mechanisms are "not economically efficient or that such procurement would lead to severe market distortions or to higher congestion"[154].

When DSOs procure – mandatorily or voluntarily – flexibility services, they have to apply market-based procedures (except if they have been granted a derogation). This is in line with the general principles of the internal energy market and the overall goal of the 2019 E-Directive that aims at integrating more energy from renewable sources, as highlighted by recital 9:

> The Union would most effectively meet its renewable energy targets through the creation of a market framework that rewards flexibility and innovation. A well-functioning electricity market design is the key factor enabling the uptake of renewable energy.

Therefore, DSOs will have to create LFMs, as already identified in section 2.2 of this deliverable. The implementation of these LFMs raises several legal questions that can be summarised as: Who is entitled to do what? In order to answer this question, use can be made of the legal framework governing the balancing mechanism as studied in section 3.1 above.

First, the actors involved in an LFM should follow the same pattern as in balancing markets: a system operator buys the services provided by FSPs – the equivalent of BSPs for LFMs – while BRPs have to pay for the issues they cause to the network (such as voltage fluctuations). However, the system operator and buyer is the DSO and not the TSO. The role of aggregation within FSPs is even more important, as highlighted in section 3.2.1. Also, there is not necessarily always a BRP. For instance, in the case of grid investment deferral services, it is a matter of avoided investments by the DSO, not of issues caused by BRPs. In addition, new small and medium actors have to be able to access flexibility markets in practice (directly or through aggregation), and especially LFMs. According to the organisation REScoop.eu, that is clearly not yet the case for energy communities [155].

Secondly, with regard to the operator: “wholesale markets are operated by third-party power exchanges, while balancing markets or other ancillary services are currently operated by the TSO”[156]. For LFMs, these two choices are possible within the current legal framework. An independent market operator can always be named as is done for the wholesale market, where a “nominated electricity market operator” or NEMO is designated by the competent authority [157]. This actor could potentially also aggregate the remaining flexibility and propose it to the TSO on the balancing markets, as suggested above in section 2.2. Some companies exist and they already operate LFMs, as shown by Schittekatte and Meeus [158]. DSOs are not prohibited from owning and operating a flexibility market platform either. However, Buchmann argues that to ensure neutral market operation by DSOs, their unbundling regime needs to be amended [159]. Buchmann also proposes a third option where LFMs are operated by a so-called “Common flexibility platform”, a cooperative body gathering all relevant stakeholders of the LFM to set its rules, such as on product requirements [160]. This is in line with the existing requirement for DSOs procuring flexibility services to establish the specificities for the expected services in a participatory process including “all relevant system users” and TSOs [161].

Thirdly, these rules should also include standardised requirements. Indeed, DSOs must define, “where appropriate, standardised market products for [flexibility] services at least at national level”[162]. Such standardisation already applies to balancing markets and authors argue that streamlining LFM interfaces can only help flexibility providers [163]. However, it is not so clear whether standardisation will always be beneficial for LFMs. It follows from the SMILE interviews conducted that for some services (e.g., voltage support) the market rules and the necessary products may vary a lot, based on technical and geographical issues (such as extension of the grid or density of the connections). Therefore, standardisation should be studied more closely, and where possible, it may be a good idea to set standard products in terms of activation time, duration or minimum size as was done through TCMs for the balancing markets [164].

In order to introduce such detailed rules, the European Commission may, together with the NRAs (grouped in ACER) and the DSOs (grouped in the EU DSO entity), adopt new distribution network codes. Article 59 (1) of the 2019 E-Regulation allows to adopt network codes for many of the above-mentioned issues: voltage control [165], congestion management including services provided by active customers, citizen energy communities and the use of aggregation and DR [166], provision of non-frequency ancillary services [167] and provision of flexibility services to DSOs [168].

3.3 Summary

This chapter has analysed the EU legal regime for balancing markets and for the development of technologies and activities facilitating the procurement of local flexibility services by DSOs, which will ultimately allow the electricity system to increase the input of variable generation from RESs to the distribution grid. This increase in generation from RESs is necessary for the decarbonisation of the electricity system, which is a key objective of both the 2019 E-Directive and E-Regulation, but it also raises challenges for system balancing and distribution grid management due to its variability.

Balancing refers to all measures taken by TSOs to ensure that the system frequency remains within a predefined stability range. To do so, TSOs have to use balancing markets where BSPs offer frequency services to cope with the situations where BRPs fail to meet their generation or consumption schedules. Balancing markets are not designed to solve local grid operation issues caused by the increasing volumes of electricity from variable RESs. We have shown that a number of improvements may be achieved, for instance by amending the 2019 E-Directive, the 2019 E-Regulation and the relevant EU network codes (EB GL, SO GL, RfG NC and DC NC) to ensure effective access to balancing markets for distributed small to medium-sized solutions relying on storage, DR and aggregation. Clear and detailed rules are needed to organise priority activation of flexibility resources connected to distribution networks by TSOs or DSOs. In any case, as balancing markets are the only flexibility markets regulated by EU law, they can serve as a model for LFMs.

Flexibility is a new term introduced into EU law by the Clean Energy Package. Flexibility services are broader in scope than balancing services. They refer to the ability to increase or decrease electricity generation or consumption as requested by flexibility service buyers, including system operators. They include balancing services, but also non-frequency ancillary services, congestion management services or grid investment deferral services. The 2019 E-Directive and 2019 E-Regulation have reinforced the existing regime or introduced new regimes for several technologies and activities enabling the use of flexibility services by DSOs. These enablers are smart meters, energy storage, DR and aggregation. The targets involving the deployment of smart meters are already 15 years old, but they have not yet been achieved in all EU MSs. It is crucial that the deployment focuses on installing meters that allow final customers to be settled in the same time resolution as the imbalance settlement period in the balancing market (every 15 minutes), as required by the legal regime. This will facilitate the exchange of data between TSOs and DSOs or between DSOs themselves on the flexibility resources available to cope with the variability of RESs. These bidirectional exchanges should be expanded and reduced to the smallest possible timeframe – 15 minutes if possible. The 2019 E-Directive guarantees that new small and medium-sized actors (active customers and citizen energy communities) will be allowed to use energy storage, participate in DR and aggregation and gain full access to all electricity markets. Effective access to the relevant markets needs to be thoroughly checked now that the 2019 E-Directive transposition has come to an end.

According to the 2019 E-Directive, DSOs have to create markets for the procurement of non-frequency ancillary services, of energy to cover their energy losses and of flexibility services (if they want to procure flexibility services at all). There are exemptions, but the rationale is that DSOs must develop LFMs to procure flexibility services for the operation and development of their grid. Flexibility services are not defined in the directive, yet it is possible to deduce from a provision that they are broader than ancillary services. The services commonly considered to be exchangeable on LFMs fall under various legal qualifications in the directive and may therefore lead to the creation of different markets with different rules – in addition to the technical and geographical disparities that also justify a differentiation between potential LFMs.

Based on the above, we aim at providing recommendations on the possible legal organisation of LFMs. First, the actors of an LFM will apply the same arrangement as in a balancing market, albeit with some adjustments. In essence, the system operator buys services provided by FSPs. However, the system operator here is the DSO, not the TSO, and the FSPs are expected to rely on aggregation to a significant extent. Additionally, BRPs may also be active, and if so, they will have to pay for the technical issues they cause to the system, such as for voltage support. Yet, there is not necessarily always a BRP. In the case of grid investment deferral services, for instance, it is a matter of avoided investments by the DSO. Secondly, an LFM can be operated by a third party, as is the case in the wholesale electricity market. It can also be operated by a DSO, similar to the role of TSOs for balancing markets. In this case, however, DSOs' unbundling rules may need to be amended to ensure their neutrality. Another solution proposed in the literature is to use a cooperative rule-making body involving all relevant stakeholders. Thirdly, the possible introduction of standardised rules and products for LFMs should be further assessed, given the large differences that can exist between the different types of services exchanged and the local needs shaped by technical and geographical characteristics. In order to organise LFMs, the European Commission, together with the NRAs (grouped in ACER) and the DSOs (grouped in the EU DSO entity), may adopt new distribution network codes.

4 From balancing to local flexibility markets in the SMILE countries

This chapter analyses the legal developments in the three SMILE countries (UK, Denmark and Portugal) and the three SMILE islands (Orkney, Samsø and Madeira) regarding balancing markets and the use of distribution-grid connected flexibility resources for the integration of more energy from variable RESs in the electricity system. It builds upon the technical and legal elements of chapters 2 and 3 and looks especially at balancing markets, enabling technologies and activities (smart meters, energy storage, DR and aggregation) and the development of LFMs. It concludes with a summary.

The study is based on information from publicly available documents and a series of interviews with the local partners.

4.1 From balancing to local flexibility markets in the UK

SMILE deliverable D7.1 already presented the policy and law-making institutions in the UK, especially the NRA (the Office of Gas and Electricity Markets (Ofgem), and the relevant ministry (the Department for Business, Energy and Industrial Strategy (BEIS)[169]. It also discussed the organisation of the network operations, with one TSO (National Grid Electricity System Operator (NGESO)) and six distribution network operators (DNOs) holding 14 distribution licences, with a focus on SSEN (Scottish and Southern Electricity Networks), operating the distribution network of Northern Scotland, including Orkney [170].

In addition, SMILE deliverable D7.3 outlined the main electricity-related elements of the Brexit agreement and introduced the December 2020 Energy White Paper [171]. This Energy White Paper reiterates that the overarching target of UK energy policy is to reach net zero emissions by 2050 [172]. To allow this, the TSO has as a main objective to facilitate a carbon free electricity system in Great Britain by 2025 [173]. This will require a massive development of generation from RESs, challenging networks operation but offering opportunities both to the TSO and DNOs.

Below we will first present the balancing markets and their recent developments in the UK, before discussing the fast evolution of the regulation for flexibility service enablers. Then, we provide the latest developments with regard to LFMs. Finally, we present the application of these regimes to Orkney.

4.1.1 Balancing markets

General balancing rules

Despite Brexit, the UK's balancing mechanism is similar to the regimes in EU MSs as the EB GL was adopted before Brexit in 2017. In fact, the 1989 Electricity Act barely mentions balancing and when it does, it refers to the EB GL [174].

In an article published in early 2020, Barbero *et al*. summarise various of the existing balancing markets in the UK [175]. It appears that there were four different types of markets only for FCR, with the same minimum bid size (1 MW), but with different notification times, maximum number of activations, duration of delivery, etc. In other words, four different markets tailored for different products, but all addressing the fastest post-fault frequency restoration services (see also figure 1 in section 2.1 above). In addition, there are several RR markets, which make use of different rules. Seen from a distance, the situation is therefore quite complex and is changing fast. At the time of writing, the TSO's website shows that the different types of FCR markets have been replaced by a new one: Dynamic Containment (DC)[176]. This change results from two main causes: harmonisation with EU balancing markets and integration of more flexibility services from vRESs and aggregated providers.

European platforms

The TSO, NGESO, was intended to be part of two of the new European balancing platforms being implemented [177]: MARI [178], for mFRR, and TERRE [179], for RR. As Bray, Woodman and Judson argue, the preparation of the participation of NGESO into these projects has required modifications of the relevant network codes in order to align Great Britain with other participating TSOs [180]. This is facilitating the standardisation of products with rather low access thresholds such as a minimum bid size of 1 MW whereas in Great Britain some existing markets require a minimum of 3 MW (i.e., for the Short-Term Operating Reserve (STOR), one of the two types of RR procured [181]). These changes indirectly facilitate the access of distributed vRESs and aggregated DR to the balancing markets [182]. However, NGESO's participation to the platforms has been put on hold since Brexit and until "ratification of free trade agreements on energy by the EU and the respective national parliaments"[183].

Opening balancing markets to distributed flexibility resources

NGESO is in the process of modernising its FCR services. The reason is the "continued growth of renewable capacity in the GB market" which has "reduced the requirement for conventional generation on the system, and [caused] a consequential decrease in system inertia, especially at times of low demand and high renewable production"[184]. In other words, more and more traditional generators using fossil fuels (such as coal or natural gas) cease operations and they therefore cannot provide the system services they used to, such as frequency services through inertia [185]. The problem is that only synchronous generators produce inertia (through turbine rotation) and wind and solar PV are asynchronous generators: they do not produce inertia. Yet, inertia used to be the fast solution to frequency variations. Therefore, in order to reach its target of a fully decarbonised electricity transmission grid by 2025, NGESO is replacing its frequency response services with a new suite of services: DC, Dynamic Moderation and Dynamic Regulation [186]. These are explicitly open to "diverse providers including variable generation, storage, and demand-side participants"[187]. DC has already been launched in October 2020 and the two others will follow soon. It should be noted that DC "is actually two services: DC-low and DC-high"[188]. This corresponds to separated downward and upward balancing services, as is requested by the 2019 E-Regulation and as mentioned in section 3.1.3 of this deliverable. This parameter facilitates the provision of services by "wind and solar, which may prefer to deliver [DC-high] only and also demand-side, which may be naturally suited to [DC-low] only"[189]. In addition to facilitating the provision of balancing services by vRESs generation, energy storage and DR, NGESO is also "looking at opportunities to further open DC and subsequent services to aggregators"[190].

As a consequence, three out of the four enabling technologies and activities that supposedly are used by DNOs to procure flexibility services (see in section 3.2.1), are also targeted by the TSO. This risks creating conflicts about the activation of the distributed flexibility resources and that is why NGESO specify that they increasingly collaborate with DNOs to "ensure that the whole system is considered before taking actions or buying services"[191]. This highlights the importance of improved TSO-DSO cooperation, as stated in section 3.2.2 of this deliverable.

4.1.2 Regulating enablers: smart meters, energy storage, DR and aggregation

The UK legal developments with regard to these four enablers are analysed below. DR and aggregation are discussed in the same paragraph as most sources consider them together.

4.1.2.1 Smart meters

Smart meters are defined in the 1989 Electricity Act as meters that can send and receive information through an external electronic communication network [192]. By contrast to the definition in EU law (see section 3.2.1 above), it does not refer to the possibility of remote control. Apart from this, the 1989 Electricity Act enables licenced electricity suppliers to provide “a smart meter communication service”[193], although there are some exemption to the license obligation. See for more detail SMILE deliverable D7.3 [194].

On 31 December 2020, there were 23.6 million smart meters in homes and small businesses in Great Britain [195]. This figure represents 42% of all meters in Great Britain [196]. The earlier mentioned Energy White Paper stated that it remains the UK’s ambition “to achieve market-wide rollout of smart meters as soon as practicable”, although without setting an end date [197]. To accelerate this deployment, Ofgem is setting new rules for suppliers [198]. Until 30 June 2021, suppliers were obliged to take ‘all reasonable steps’ to rollout smart meters. From July 2021, suppliers will have to comply with binding annual installation targets. “Failure to achieve the annual installation targets will be a breach of a supplier’s licence”.

In addition to accelerating and better controlling the rollout of smart meters, Ofgem has also decided in April 2021 to extend the deployment of half-hourly settled smart meters to the market, “including for domestic customers for whom it was optional until now”[199]. It aims at achieving the full deployment of these advanced smart meters by October 2025 [200]. By end 2020, only 1.3 out of the 23.6 million smart meters deployed were considered as advanced smart meters and thus able to perform the half-hourly settlement [201]. The deployment of these advanced smart meters is necessary to allow all households and small businesses to access real-time prices and potentially to become FSPs, as raised by the Energy White Paper and by the interviewed SMILE partners deploying smart technologies in the UK [202].

4.1.2.2 Energy storage

Since presenting the SMILE deliverable D7.1 in 2019, UK legislation on electricity storage has not changed much [203]. Ofgem’s October 2020 decision on clarifying the regulatory framework for electricity storage has adopted the proposed power-to-power definition: “Electricity storage is the conversion of electrical energy into a form of energy which can be stored, the storing of that energy, and the subsequent reconversion of that energy back into electrical energy”[204]. Electricity storage is therefore now integrated into the generation licence and electricity storage operators need a licence and have to provide information regarding their facility to their supplier [205]. This definition of electricity storage has also been integrated into the Grid Code [206], but is still pending its inclusion in law, when Parliamentary time allows [207].

With regard to the use of storage for the provision of flexibility services, the new balancing market – DC market presented in section 4.1.1 above – proves to be very attractive for battery technologies [208]. The first procurement round initiated by NGESO, led to BSPs securing the provision of DC services at “prices significantly higher than those accepted in other frequency response service auctions”. Two elements of this new market proved very favourable for the use of batteries: the tendering period and non-symmetricity. First, DC is tendered day-ahead, allowing BSPs “to take a view of alternative markets and opt in or out of them to maximise revenue”. In other words, battery operators can study the market conditions on the day before and choose to offer their services where it is most profitable, being on a balancing market or directly on the wholesale market. This is what happened in January 2021 in Great Britain where battery operators could switch to the wholesale market when prices reached high levels. Secondly, symmetricity is not required on the DC market, meaning that upward and downward power are procured separately, as indicated earlier in section 4.1.1. This rule allowed BSPs to place bids for charging their battery (downward balancing) on a market and bids for discharging it (upward balancing) on another, offering their services where most needed and securing higher gains – an activity also labelled as benefit stacking. The importance of symmetricity in the level of revenues is confirmed in other research [209]. These two elements are good practices that should be adopted in all flexibility markets, from balancing to LFMs, in order to facilitate the uptake of generation from vRESs and the development of flexibility resources.

4.1.2.3 Demand Response & Aggregation

Already in the SMILE deliverable D7.3, we referred to two recent reports assessing the options for the provision of flexibility services in Great Britain [210]. It appears that while aggregation is enabled for most of the balancing services, the participation of independent aggregators is limited. In addition, Barbero *et al*. argue that while the "UK was one of the first countries to incorporate DR solutions in Europe, the market is yet immature and the capacity of DR is decreasing each year, risking to disappear in the future"[211]. The same authors also argue that the aggregation of small-size batteries to provide DR services can substantially increase the revenues of aggregators and reduce the number of clients necessary to reach the minimum bid size [212]. Moreover, Rae, Kerr and Maroto-Valer show that over the past years, energy storage and transport (especially through EVs and smart charging) have become the main focus of community energy projects in the UK [213]. These lines show that the provision of DR services by aggregators needs to be further facilitated by legislation but that there is strong potential, especially with the ongoing deployment of distributed flexibility resources.

4.1.3 The development of local flexibility markets

In the last decade, distribution networks in Great Britain have seen a strong increase in the connection of generation assets using vRESs [214]. Given the UK decarbonisation targets, this will not stop, rather the opposite. This is creating issues for the operation of these grids, such as "voltage deviations, line losses, system balance and reserve issues, robustness and power quality"[215]. But this influx also creates opportunities as it is accompanied by new flexibility resources being connected to the distribution networks [216]. This evolution rendered necessary the progressive transformation of the British DNOs into DSOs, from solely managing a network to managing a system with more parts, more actors, more targets and more activities. A transformation that is set to be achieved by 2029 [217]. According to the Energy Networks Association (ENA), DSOs operate active distribution systems with flexible distributed energy resources and act as neutral market facilitators enabling the participation of all actors to LFMs [218]. Therefore, DSOs and LFMs are intertwined.

Actually, LFMs are already being used by DNOs all over Great Britain. Since 2010, LFMs have been deployed as demonstration projects [219], such as the Cornwall Local energy market which has shown that LFMs are "feasible and viable"[220] and has provided many lessons we will present below. Yet, since 2018 all Great Britain's DNOs procure flexibility services through tenders [221] and in 2020 alone, DNOs "awarded contracts for around 1.2GW of flexibility services" through LFMs [222]. The national energy policy requires from DNOs to open their networks to "more local solutions and [to] open up as many services as possible to competition"[223]. In this regard, the ENA has been charged by Ofgem and BEIS in 2019 to organise the introduction of LFMs [224]. As a part of this task, ENA has recently published a standardised methodology to help DNOs evaluate solutions for congestion management, including flexibility and traditional grid reinforcement options [225]. Consequently, currently the development of LFMs in the UK is mostly organised by DNOs, under the control of Ofgem and BEIS.

However, if the development of LFMs in the coming years is not satisfactory, the Government will opt for a legislative process [226].

As mentioned above, the Cornwall project provided many lessons and recommendations, which could benefit legislators in the UK, in the EU and in EU MSs [227]. We selected the most relevant recommendations and added information from other sources as well as feedback from conversations with SMILE project partners.

Networks governance in the context of decarbonisation

The current approach to distribution network governance by Ofgem and BEIS is considered by Bray, Woodman and Judson to be inadequate [228], as:

> the current silo thinking of BEIS and Ofgem is not fit for purpose, and a more holistic, strategic approach is needed. Instead of thinking about how to address individual problems as they are identified, there needs to be a clear vision about how to deliver networks which will allow the electricity system to deliver net-zero generation as rapidly as possible [229].

Ofgem and BEIS, as well as other legislators and NRAs in Europe should always keep in mind the overarching target of decarbonising the electricity system and the rest of the economy and not only evaluating a reform on a monetary basis [230]. If it is assessed that LFMs are both environmentally and economically the best way forward for a specific type of service in a limited geographical context, this should be the preferred choice. However, prioritising the establishment of a level-playing field above all other criteria may end up being counter-productive and slow down the transition. For instance, in some cases the area where flexibility is needed only has a limited number of customers and would not be suitable for an LFM. For such locations, the DNO UKPN would prefer administratively set service prices [231].

LFM operation model

The operation of LFMs has been raised before in sections 2.2 and 3.2.3. In the UK, the experience from various DNOs shows that they currently act as neutral facilitators and only as buyers on the LFMs. At least three LFMs use a flexibility platform operated by a third-party (Piclo in these cases) and others also operate LFMs in Germany, the Netherlands and Norway [232]. In any case, DNOs must publish their flexibility needs so that potential FSPs can estimate the services they can provide. For instance, UKPN has done so in 2019 for three services: grid investment deferral in addition to so-called "managing planned maintenance, and responding to (unplanned) network outages"[233].

TSO-DSO cooperation

The Cornwall pilot has shown that gathering flexibility services to be used both by the DNO and the TSO is possible [234]. In this LFM, the platform coordinated the procurement by network operators "whilst ensuring that conflicting resources were not simultaneously dispatched, and that contracts for national services did not increase or create congestions at the local level". This issue of conflicting use of distributed flexibility resources and the need for TSO-DSO cooperation and clear rules was raised earlier in this deliverable in sections 2.2 and 3.2.2. This pilot project should therefore be analysed by interested parties in other jurisdictions.

Standardisation

One of the national energy policy objectives is to implement standardised flexibility products [235]. Hence, Ofgem and BEIS required ENA to take steps "to ensure that new flexibility markets and products are co-ordinated with each other and with other electricity markets – including balancing and network services procured by the ESO"[236]. The question of standardisation has been mentioned earlier in this deliverable, both for balancing markets and LFMs [237], especially to underline that what is good for the former is not always so for the latter. However, UKPN lists a few flexibility product requirements from previous flexibility service procurements that could be used as standards. In a 2017 tender, UKPN used a 100 kW minimum bid size [238], which is much lower than the average minimum bid size of 1 MW for balancing markets and allowed for use of aggregation to reach this size [239]. In following tenders, UKPN decided to authorise the stacking of revenues: FSPs can offer services on different markets, under some conditions [240], and could therefore secure higher revenues as battery operators do on the DC market presented in section 4.1.2.2 above. These experiences can serve as recommendations for DNOs in the UK and DSOs in the EU. The 2017 experience of UKPN has also reinforced the importance of having half-hourly settled smart meters, as FSPs have to provide a "proof of delivery" after having effectively provided their services in order for the DNO to check the reality of the service and to realise the payment [241]. This need for a proof of delivery for all flexibility service procurements was confirmed by one of the SMILE partner during an interview.

Curtailment vs LFMs

Some DNOs use flexible connections to accelerate the connection of generation from vRESs [242]. The principle is to authorise the connection of generation even if grid capacity would usually impede it, at the condition that this installation will be the first to be curtailed when the grid is constrained. Bray, Woodman and Judson, from the Cornwall project, argue against flexible connections [243]. They argue that they disincentivise the use of LFMs and possibly stifle the development of more distributed generation from vRESs. Indeed, where such flexible connections have been introduced, "DNOs will not award contracts for 'turn-down' services as they are simply able to curtail generation themselves without procuring a market service". Part of the wind production on Orkney is facing this situation as will be discussed in section 4.1.4 below. NRAs should therefore control the use of flexible connections and rather adopt a holistic view as mentioned earlier in this section.

Finally, the Cornwall project gave rise to a couple of other recommendations which are worthwhile mentioning. First, it is prudent to register all distributed energy resources (i.e., generation and flexibility resources) of all sizes in order to better plan network improvement and maintenance [244]. Secondly, the reduction of local grid tariffs (DUoS in the UK) for locally exchanged generation should be considered, potentially incentivising the creation of more LFMs. This was rejected so far by Ofgem [245].

4.1.4 Application of the regime on Orkney

The DNO for Orkney is SSEN, which also covers the north of mainland Scotland. In the last decade, total generation capacity from vRESs, especially onshore wind, connected to the distribution grid in the region has skyrocketed [246]. In Orkney, all generation is connected to the distribution grid and counts 50 MW from wind and 1.4 MW from solar PV as explained in SMILE deliverable D7.3 [247]. This increase will continue following the 2019 Scottish Climate Change Bill that aims at net-zero emissions by 2045, five years before the rest of the UK [248].

SSEN widely uses flexible connections in order to facilitate the connection of more renewable generation [249]. This type of connection has been used since 2011 in constrained areas and proposed to all customers since 2019 [250]. Flexible connections have been used on Orkney since the creation of an active network management system in 2009 and due to severe connection restrictions between 2011 and 2020 [251]. It led to massive losses for some community-owned wind turbines on the islands, curtailed up to 80% of the time without compensation [252]. As argued by Bray, Woodman and Judson in section 4.1.3 of this deliverable, SSEN should investigate the possibility of setting an LFM on Orkney for congestion management instead of simply curtailing local wind turbines without compensation.

SSEN has identified so-called Constraint Managed Zones (CMZ) where technologies provide "flexibility to alleviate network constraints, deploying them as an alternative to traditional network reinforcement in the management of peak demand"[253]. Yet, only one CMZ is identified on part of Orkney, St Mary [254], while other areas could arguably be identified as such and potentially the entire island could act as a CMZ. SSEN also identifies a need for voltage control services in order to cope with the increase in generation from vRESs [255]. This could be a reason to set up an LFM to provide such services in Orkney.

Given the situation in Orkney, various flexibility services could actually be procured through LFMs. This would be especially adapted given the existing flexibility resources thanks to the SMILE project. In SMILE deliverable D7.3, we already counted around 800 kW of controllable load from households and EVs in only one zone of the network [256]. SMILE partners estimate that the existing resources are already used or can easily be used to provide services related to congestion management or voltage support, but not for balancing services even when aggregated, given that the minimum bid size requirement (1 MW) is too high. A more recent project is planning to "combine up to 500 domestic batteries, 100 business and large-scale batteries, up to 600 new electric vehicles, 200 vehicle-to-grid chargers, 100 flexible heating systems and an industrial hydrogen cell"[257]. As ample flexible resources are available, SSEN should get more involved in using these resources, allowing for more connection of generation from vRESs and guaranteeing that electricity producers from RESs actually can sell their production and by doing so accelerate the decarbonisation of the electricity system.

4.2 From balancing to local flexibility markets in Denmark

The institutional framework related to the energy transition in Denmark was presented in SMILE deliverable D7.1 [258]. The main objective guiding energy developments in the country is to reach 100% electricity consumed from RESs by 2030 and 100% energy from renewable sources by 2050. In 2019 and 2020 already, slightly more than 50% of the electricity consumed came from RESs, especially wind and solar [259]. The electricity system has to be able to handle high shares of vRESs, especially as the volumes will increase, with an estimate of 90% of the electricity produced in 2050 coming from wind energy alone [260]. Mindful of this challenge, the 2011 Energy Strategy of the Government the need for flexibility, but only once, when providing the example of EV smart charging [261]. However, policy developments on this topic accelerated and the 2018 Energy Agreement has a separate section on "a smart and flexible energy system" and also foresees the deployment of a "market model 3.0"[262]. More recently, the 2019 integrated National Energy and Climate Plan (NECP) refers extensively to flexibility, energy storage and DR [263].

As Denmark is an EU MS, the entire legal regime presented in chapter 3 is fully applicable. The cornerstone of the national electricity legislation is the Electricity Supply Act (*Elforsyningsloven*) as most recently amended on 6 February 2020 [264].

4.2.1 Balancing markets

General balancing rules

As discussed in SMILE deliverable D7.3, Denmark is divided in two supply areas: Western Denmark (DK1) and Eastern Denmark (DK2)[265]. These form two electricity markets with different rules. DK1 is part of the Continental Europe synchronous area and DK2 of the Nordic region synchronous area. As appears in table 1 below, balancing markets on DK1 encompass FCR, aFRR and mFRR, but there is no RR. DK2 offers to exchange frequency on frequency-controlled normal operation reserve (FCR-N), frequency-controlled disturbance reserve (FCR-D), mFRR and since late 2020, fast frequency reserve

(FFR)[266]. The table provides information about the products' technical requirements, such as minimum bid size, order of activation, duration or symmetricity.

Table 1: Balancing markets and products requirements in Denmark (amended)[267].

DK1 (Western Denmark)					
FCR	1	Hourly	20 mHz < |Δf| < 200 mHZ	Availability payment (marginal bid) + imbalance settlement	Daily auctions. Asymmetrical service. Offers to be submitted for 4-hour blocks. Same bid for hours within one block.
aFRR	1 (max. 50)	Hourly	After FCR	Availability payment (pay-as-bid) + marginal settlement[22]	Monthly bilateral contracts. Symmetrical product. Energy and capacity market.
mFRR	5 (max. 50)	Hourly	After aFRR	Availability payment (marginal bid) + marginal pricing (equal to the balancing price)	Daily auctions. Asymmetrical product. Energy and capacity market
DK2 (Eastern Denmark)					
FCR-N	0.3	Hourly	0 mHz < |Δf| < 100 mHz	Availability payment (pay-as-bid) + marginal pricing (equal balancing price)	Daily auctions. Symmetrical product. Offers can be submitted for single hours or block of 3 or 6 hours. Energy and capacity market.
FCR-D	0.3	Hourly	49.5 Hz < f < 49.9 Hz	Availability payment (pay-as-bid) + imbalance settlement	Daily auctions. Asymmetrical service. Offers can be submitted for single hours or block of 3 or 6 hours.
mFRR	5 (max. 50)	Hourly	After FCR	Availability payment (marginal bid) + marginal pricing (equal to the balancing price)	Daily auctions. Asymmetrical product. Energy and capacity market.
FFR	0.3		f < 49.7 Hz f < 49.6 Hz f < 49.5 Hz[23]	Yet to be determined	-

European platforms

Denmark is involved in most of the new European balancing platforms as discussed in section 3.1.4. First, Energinet is involving DK1 in the voluntary platform to procure FCR from a common pool of resources [268]. The rules for this platform slightly differ from the rules for the FCR market in DK1 as presented in table 1 above. For instance, the European platform requires symmetric products. In this regard, the European platform could follow Denmark's track and authorise asymmetrical products and lower the minimum bid size to 300 kW as for FCR-N and FCR-D in order to allow the participation of more flexible resources. Secondly, Energinet is part of the European aFRR common platform: PICASSO [269]. However, this platform is still being developed as its operation date is scheduled for July 2022 [270]. In parallel, Denmark is involved in the project of Nordic aFRR capacity market, pooling resources between Norway, Sweden, Finland and Denmark [271]. When launched in early 2022, it will only include DK2, but in the future, DK1 will be able to join too. This regional market will allow to make use of hydropower as the most sizeable existing balancing resource present in parts of Norway and Sweden. Thirdly, Denmark is part of another platform project, aiming at sharing mFRR resources: MARI [272]. This market is also to be launched early 2022 [273]. Finally, Energinet also participates in an older project: the Imbalance netting platform, or IN [274]. This platform was initially launched in 2010 with only a handful of TSOs but it has expanded progressively. It allows at avoiding the simultaneous activation of FRR resources in opposite directions. Such mechanism is increasingly relevant for TSOs and DSOs in order to avoid simultaneous activation of flexibility resources.

Opening balancing markets to distributed flexibility resources

As mentioned earlier in sections 3.1.2 and 3.1.3, balancing markets in the EU are evolving and must be open to a variety of resources, including vRESs and other distributed flexibility resources. In 2020, an experiment organised by Energinet has proven that wind turbines can offer upward and downward frequency services on the mFRR balancing market [275]. This was made possible thanks to constant progress in forecasting electricity generation. Energinet announced that the experience gained "is expected to be implemented in the national market designs for ancillary services by the end of 2021". This would mean that the current prohibition made to wind turbines and solar PV panels to offer frequency services without the support of guaranteed generation could be lifted [276]. However, other flexibility resources and particularly the small and medium ones – such as batteries – connected to the distribution grid, could offer balancing services but it is not easy. As table 1 has shown, some products still have to be symmetrical – aFRR in DK1 and FCR-N in DK2 – therefore able to provide upward and downward services, which is inconvenient for DR. This should change soon as article 6 (9) of the 2019 E-Regulation requires upward and downward balancing to be procured separately, except for derogations granted by the NRA [277]. In practice, balancing services offered by energy storage assets and especially batteries have so far not been developed to such an extent as in the UK [278]. This is due to several reasons (such as lower balancing prices in Denmark) but primarily because specifically tailored markets for storage have not been designed yet. Energinet and the Danish NRA may find it helpful to study the UK case in order to better harness the potential of storage in general and electricity batteries more specifically.

4.2.2 Regulating enablers: smart meters, energy storage, DR and aggregation

The Danish legal developments with regard to these four enablers are analysed below. Similarly to the UK, Danish sources often consider DR and aggregation together so we present them in the same paragraph.

4.2.2.1 Smart meters

Danish law already required DSOs in 2013 to install smart meters at all consumption points by end of 2020, with the capacity to measure electricity injection to and withdrawal from the grid every 15 minutes [279]. The regime for smart meters is now included in a Ministerial Decree of January 2019 [280]. It confirmed the 2020 target and the 15-minute timescale and developed the applicable regime in more detail. This regime complies with the EU law definition of smart meters and with the required imbalance settlement period of 15 minutes as explained earlier in section 3.2.1. Yet, for the moment, system operators have implemented an hourly settlement model ('*flexafregning*') proposed to all consumers [281], but not a 15-minute one.

By end of 2020, close to 100% of the Danish consumers were equipped with a smart meter [282]. As a result, Danish suppliers can propose various types of contracts that can be organised in two categories: hourly or quarterly settled [283]. The first category therefore refers to dynamic contracts following the evolution of market prices [284]. This is made possible by the large scale introduction and use of smart meters. This successful deployment also enables market parties to make use of flexibility resources connected to the distribution system, amongst which energy storage and the activities like DR and aggregation.

4.2.2.2 Energy storage

Since the publication of SMILE deliverable D7.1, the legislation governing storage in Denmark has evolved [285]. By then it was not even mentioned. However, the 2019 E-Directive was transposed in

Danish law at the end of 2020 and consequently introduced several new concepts and definitions, including on energy storage (*Energilagring*)[286]. The Danish definition is similar to the EU one. Specific grid connection rules also apply to storage and are set by Energinet [287].

In terms of policy, the main documents presenting the pathway to 2050 do not rely on local energy storage through batteries but on hydropower pumping stations in Norway and Sweden and to some extent on EVs' smart charging [288]. Yet, the 2019 NECP refers various times to energy storage, stating as an objective to "support structures that favour […] energy storage markets"[289]. In addition, the Danish Government established a fund supporting development and demonstration projects on energy storage. These funds have been granted to two Power-to-X projects producing and storing green hydrogen in December 2019 [290].

Aside from the legal and policy aspects, energy storage needs a business case. According to a recent report, the Danish FCR balancing market offers "a positive business case for Lithium-Ion batteries in 2025" in both DK 1 and 2 [291]. Aside from the balancing services, most of the other services that can be offered by batteries are not remunerated, save for black start and independent-supply, as detailed in SMILE deliverable D7.3 [292]. Yet, electricity storage is already recognised as a good method for providing voltage regulation, especially at medium to low level networks [293]. Energy storage through batteries should also become more economically interesting with the new hourly electricity price structure mentioned in section 4.2.2.1 above [294].

To allow for an accelerated development and use of energy storage and especially batteries in Denmark, recent literature provides relevant recommendations. Indeed, given the expected growth in electricity production from wind energy, "a significant growth within various energy storage solutions is forecasted in Denmark" in order to provide both upward and downward regulation [295]. To do so, the legal framework must ensure that "the pricing signal is attractive for flexibility resources", that the stacking of revenues for battery storage is authorised and that flexibility markets reduce the product requirements' duration to one hour or less [296]. These broadly fall in line with the EU level recommendations already provided in section 3.3 of this deliverable.

4.2.2.3 Demand Response & Aggregation

DR and aggregation are not only often considered together, but also in relation to common issues such as prosumers. In the 2019 NECP, DR and aggregation activities are mentioned various times and often together. According to this document, the development of DR is an objective of the Danish energy policy and the electricity market is open for participation of DR, including via aggregation [297]. Denmark is also "constantly seeking to improve market regulations" in order to encourage the participation of aggregated DR, including through the recent development of "an aggregator model allowing decentralised resources to participate in energy and ancillary services markets"[298]. In addition, DR is made possible through the deployment of smart meters, economic incentives provided by new tariffs (*Flexafregning*) and electrification of the district heating system [299].

Yet, although aggregation (*Aggregering*) is defined in the legal framework [300], this is not the case for DR. At best, one can find a mention of demand side management – which is a similar concept – in the Act amending the Electricity Supply Act [301]. The provision considers that when planning its network development, a DSO must assess whether demand side management measures or distributed generation can replace the need for capacity expansion. As a next step, DNV GL proposes to elaborate a joint Nordic energy transition planning regime in order to coordinate the development and use of flexibility resources in the entire region [302].

However, the development of DR and aggregation has so far been slow in Denmark. Contrary to the claims in the NECP that "[t]here are no specific barriers in Danish law that inhibit independent service providers to enter into a contract with a customer, or aggregators from offering demand flexibility"[303], a late 2020 report indicates that the "main role for prosumers in Denmark is self-consumption and on-site optimisation" due to the fact that electricity prices are high while the "use of flexibility is limited due to several barriers for independent aggregation"[304]. Selling flexibility services is apparently "only possible through pilot projects" for small and medium-sized providers [305]. Ma, Værbak and Nørregaard Jørgensen acknowledge this for the pre-2020 situation, when the hourly tariffs entered the market [306]. At the moment, it is difficult to perceive the changes brought by the recent legal reforms and by the new possibility for consumers to also contract time-of-use tariffs with the DSOs [307].

4.2.3 The development of local flexibility markets

The Danish NECP refers several times to the procurement of (local) flexibility services through market-based solutions and even specified that DSOs are to act as neutral market facilitators [308]. These policy aims have been converted into law at the end of 2020, when the 2019 E-Directive was transposed by the Act amending the Electricity Supply Act [309]. According to the new provisions, DSOs must act as neutral market intermediaries when acquiring the electricity they use to cover their network losses in accordance with transparent, non-discriminatory and market-based methods. The process must be detailed by the Minister of Climate, Energy and Utilities. The same ministry also lays down the rules on DSOs' acquisition of non-frequency ancillary services and flexibility services through transparent, non-discriminatory and market-based methods. For the procurement of non-frequency ancillary services and flexibility services, DSOs must cooperate and coordinate with Energinet. Therefore, Danish law complies with EU law as presented in section 3.2.3 of this deliverable and should soon lead to the creation of various LFMs.

Together with the amendment of the Electricity Supply Act, the Ministry of Climate, Energy and Utilities also adopted an Executive order in which it sets detailed rules for the procurement of the abovementioned services by DSOs [310]. Whereas chapter 4 of the Order applies to the procurement of electricity to cover grid losses, chapter 5 regulates the procurement of non-frequency ancillary services and chapter 6 refers to the procurement of flexibility services. The requirements for the procurement of electricity to cover grid losses are fairly simple and mainly consist in organising a tender where price is the decisive criterion [311]. The procurement rules for non-frequency ancillary services and flexibility services are a bit more developed but follow the same model. In both cases, the DSO has to procure the needed services through transparent, non-discriminatory and market-based methods approved by the NRA [312]. The procurement procedure must follow three steps [313]. First, the requested services are advertised to all potentially interested market participants. Secondly, all qualified market participants must have free and equal access to the market and can effectively participate on equal terms. This requires technology neutrality of the procured services. Thirdly, the DSO enters into an agreement with the market participant offering the lowest price for the service in question and meeting the technical requirements. These technical requirements are to be determined in close cooperation with Energinet and other relevant DSOs and with the open and transparent involvement of all qualified market participants. Also, it specifies that organisations in the energy industry (such as Dansk Energi) may prepare standardised guidelines for determining the procurement methods [314], therefore facilitating standardisation between LFMs where adequate.

The regime for the procurement of flexibility services benefits from a few distinctive points compared to the procurement of non-frequency ancillary services. First, it provides for a derogation to the market-based procurement requirement, if validated by the NRA [315]. Secondly, DSOs explicitly have to lay down the specifications for the procured flexibility services, including conditions such as the type of flexibility service, the size, the duration, the response speed, the measurement accuracy, the geographical location and the voltage profile of the requested service [316]. Thirdly, DSOs can jointly set standardised market products at a national level, in cooperation with Energinet and all market participants [317]. Fourthly, they must in any case exchange all necessary information and coordinate closely with each other and with Energinet to ensure optimal utilization of resources, guarantee safe and efficient operation of the national electricity network and promote the development of flexibility markets [318]. Therefore, it seems that the development of flexibility services and of LFMs accelerates, strengthens TSO-DSO coordination and also opens the door for DSO-DSO coordination, as highlighted earlier in this deliverable in sections 3.2.2 and 3.2.3.

The Order also provides some information with regard to flexibility services and DSOs. By contrast to the 2019 E-Directive and E-Regulation [319], Danish law defines flexibility services as follows:

> [A] service that a market participant provides to a [DSO] pursuant to an agreement for payment or consideration. The service may either consist of a change in the market participant's or its customers' purchase of electricity from or supply of electricity to the [DSO's] network or in a change in the market participant's or its customers' rights to purchase electricity from or supply electricity to the [DSO's] network. The change can in all cases be triggered by either the market participant, the customer or the [DSO] [320].

Moreover, article 8 of the Order requires that a DSO's development plan contains an inventory of the expected need for alternative solutions to grid investments such as flexible electricity consumption, energy efficiency, energy storage facilities or other resources. This corresponds to the aforementioned grid investment deferral service [321]. The expected flexibility needs must be quantified and stated in relation to a time horizon of 0-2 years, 2-5 years and 6-10 years. This is another potential LFM to be created although here the procurement rules are not specified.

The EU law requirements for market-based procurement of flexibility services by DSOs have quite recently been fully transposed. The Act amending the Electricity Supply Act and the Executive Order entered into force on 31 December 2020, with an extension to 1 January 2022 for the market-based procurement of electricity to cover grid losses [322]. Although Denmark to some extent has gone beyond the EU requirements it is at the time of writing not clear what the impact is on the creation of LFMs by Danish DSOs.

So far, it seems that LFMs have mainly been initiated as pilots for local congestion management [323] or for offering active power as aggregated DR services [324]. Our research did not show any proof of an organised system of flexibility service tenders by Danish DSOs as is the case in the UK [325]. The DSOs' webpages do not advertise any information about flexibility services' needs. This confirms our analysis in the SMILE deliverable D7.3 that voltage regulation, reactive power effect compensation and network adequacy services are not yet procured via markets, thus limiting these opportunities [326].

Finally, the issue of standardisation is mentioned in the above legislation and keeps coming back as a recommendation in various documents consulted [327]. As proposed in the Executive Order, standardisation of the LFM rules and especially with regard to the relevant products is a possibility. This was also proposed in section 3.2.3 of this deliverable. Yet, some of these services are local by nature and cannot be transported over long distances, such as reactive power for voltage control [328]. In the same section, one of the SMILE partner highlighted that standardising rules for such services may be counter-productive. Therefore this should be carefully studied before engaging in standardisation of the still-to-emerge Danish LFMs.

4.2.4 Application of the regime on Samsø

According to Samsø's energy policy document – Samsø Energy Vision 2030 – the island aims to reach 100% of renewable energy consumption in 2030 [329]. To do so, it looks at flexibility offered by gas and liquid storage, at using EV batteries and at harnessing district heating as buffers but discards stationary electricity storage through batteries as these are considered too expensive. The island has no relevant specific regulation.

As discussed in section 3.4.2 of SMILE deliverable D7.3, the Ballen marina consists of a 60 kWp solar PV plant, a 200 kWh battery with a 49 kW converter and smartened heat pumps at the warehouse' building and the sauna. Yet, these are only used for balancing the internal grid of the marina through self-consumption. To provide flexibility services to the local DSO (KONSTANT) or to Energinet, various barriers would have to be lifted. First, the battery could be expanded in order to accumulate more capacity and deliver more power at once. For this to happen, a reasonable business case is needed. This is presently not the case as most potential flexibility services are not remunerated and even energy arbitrage is currently not profitable [330]. Secondly, the 50 kW limit on export to the grid set by the DSO should be renounced. As Samsø is part of the DK1 area, the lowest size for a balancing service is 1 MW, as shown in table 1 above. Currently, the Ballen marina could at best provide such a service through aggregation. The marina could theoretically also offer more services to the local area and especially to KONSTANT. SMILE partner DTI argues that voltage control services will be increasingly needed in the future with households investing in PV panels, heat pumps and EVs, but until there is a market for such services, the DSO cannot procure them. Given that Samsø aims for 100% of renewable energy consumption in 2030, flexibility needs may arise sooner than on the mainland and it would thus be appealing to develop an LFM on the island. DTI added that to enable local LFMs it would make sense to start creating a national generic framework to avoid having too many local rules. The services procured through the LFM could then be tendered for a smaller geographical area, e.g. for each DSO substation. Moreover, lessons can be learned from the conclusions and recommendations offered by the Ecogrid 2.0 project that took place on the Danish island of Bornholm [331]. One of the conclusions is that small final customers are primarily interested in comfort and costs of their electricity supply, and not so much in aggregation and the supply of services which are unpredictable and difficult to explain [332]. A local SMILE partner added that LFMs are not very "people-oriented" and that such a system would rather be in the realm of companies and not based on direct involvement of citizens.

4.3 From balancing to local flexibility markets in Portugal

SMILE Deliverable D7.1 presented the institutional framework for energy governance as well as the main Portuguese energy policy documents [333]. The country's main policy objective is to reach carbon neutrality by 2050 [334].

This section is organised as the previous ones, starting with the balancing regime before turning to an analysis of the regulation of flexibility enablers to provide balancing or – more generally – provide flexibility services to system operators and the potential creation of LFMs. In the case of Portugal, the situation on the SMILE island of Madeira differs from the mainland given the specificity of the island's legal regime.

4.3.1 Balancing markets

Portugal is an EU MS, meaning that the legal regime detailed in chapter 3 fully applies. The main legal text governing the electricity sector is Decree-Law (DL) 29/2006 of which the most recent consolidated version dates from 1 October 2020 [335]. So far, by contrast to the 2018 RES-Directive that was transposed into Portuguese law by DL 162/2019 [336], the 2019 E-Directive has mostly not been implemented yet [337]. As the following paragraphs will show, this sometimes causes the Portuguese electricity legal framework to be rather inadequate with regard to the use of flexibility resources by system operators.

General balancing rules

System balancing in Portugal is regulated by various legal texts. While the Decree-Laws 29/2006 and 172/2006 form the legal basis [338], the regime is mostly set by regulations published by the NRA (ERSE): the ROR (Regulation on network operation - *Regulamento de Operação das Redes*), the RRC (Regulation on commercial relations - *Regulamento das Relações Comerciais*) and the MPGGS (Manual of procedures for the management of the system - *Manual de Procedimentos da Gestão Global do Sistema*).

System services (*Serviços de sistema*) are defined by article 3 (kk) of the DL 29/2006 as the means and contracts used for the secure and safe operation of an electricity system, excluding those that are technically reserved to the TSO. Such services can be provided by electricity producers through a (bilateral) contract with the system operator or via the participation to a dedicated market [339]. DL 172/2006 specifies that the system services market must be operated on the basis of efficient, transparent and competitive mechanisms relevant for the operational reserve of the system, congestion management and to compensate electricity consumption and production deviations. In other words, these principles apply to balancing markets [340]. It is to be noted that the rules do not explicitly mention market-based mechanisms, although the term "competitive" is quite similar.

The ROR establishes that system operation is a task of the TSO, including the operation of the system service markets [341]. As in DL 172/2006, the procurement of system services must use efficient, transparent and competitive mechanisms that allow for the participation of production and consumption [342]. The list of system services is set by article 32 (2) of the ROR and includes voltage regulation (*Regulação de tensão*), primary frequency regulation (*Regulação primária de frequência*), secondary regulation (*Banda de regulação secundária*), regulation reserve (*Reserva de regulação*), fast interruptible load (*Interruptibilidade rápida*), and so on. This list seems to include various types of ancillary services similar to the ones in the 2019 E-Directive [343] and is therefore broader than a list of only frequency services. It is important to note that voltage regulation and primary frequency regulation services have to be provided free of charge [344]. The other services can be remunerated [345]. For balancing, this reduces the list of possibly remunerated services to secondary regulation and regulation reserve. For detailed rules on the management and procurement of system services, the ROR refers to the MPGGS [346].

The MPGGS contains some important definitions relevant for the balancing markets. For instance, it defines the *Agente de Mercado* [347], which is the equivalent of the BSP in EU law. It also defines the term production unit (*Unidade de Produção*), which is limited to hydroelectric or thermal turbines [348], and balancing area (*Área de Balanço*) as a set of units connected to the same network area and pertaining to the same BSP, which aggregates production capacity (and consumption in case of hydro pumping)[349]. It is clear that balancing services in Portugal are expected to be provided by hydroelectric and thermal plants. This is confirmed by Procedure 5 of the MPGGS which lists the balancing areas, which all involve these technologies [350]. In addition, whereas procedures 10 and 11 provide the rules for the obligatory and non-remunerated voltage regulation and primary regulation services, procedures 12 and 13 regulate the secondary regulation and regulation reserve. In case of the latter, the services are procured through market mechanisms [351]. Both markets are day-ahead markets and allow for the exchange of services measured in MW [352]. This suggests that similar to several other balancing markets in the EU [353], the minimum bid size is set a 1 MW, although this has only been clearly established for the regulation reserve [354].

European platforms

ENTSO-E stated in a report of 2020 that the Portuguese regulatory authority has not approved the terms and conditions defined in Article 18 of the EB GL [355]. This article sets the TCMs that have to be approved by TSOs and NRAs and has been discussed in more detail in SMILE deliverable D7.3 [356]. These TCMs contain many key elements to be transposed in the national balancing setup, for instance about DR aggregation and storage activities having to be considered as potential BSPs [357], which currently are not allowed in Portugal as indicated in the previous paragraph. The participation of the Portuguese TSO (REN) in some European balancing platforms (see section 3.1.4 above) should facilitate the application of these European standards in Portugal. REN is part of PICASSO (on aFRR), MARI (mFRR), TERRE (RR) and the IN (Imbalance Netting). It should therefore share the frequency capacities with all markets, except for the voluntary FCR platform.

Opening balancing markets to distributed flexibility resources

As mentioned in sections 3.1.2 and 3.1.3, balancing markets in the EU are evolving and must be open to a variety of resources, including vRESs and distributed flexibility resources. However, as mentioned in the previous paragraphs, the legal regime in Portugal is not facilitating these technologies. Balancing is exclusively provided by thermal and hydroelectric generators and vRESs, storage or demand are excluded from the procurement, either explicitly or in practice. In addition, primary reserve is not remunerated. This should change in order to allow for the integration of new flexibility resources into the frequency markets. Yet, there are some signs that the door is slowly opening.

First, article 17 (2) of DL 162/2019 on self-consumption provides that the network operator has to facilitate the participation of self-consumers to the provision of system services on organised markets or bilaterally, directly or via an independent aggregator, a market facilitator or a supplier aggregating production. This provision should facilitate the use of distributed flexibility resources by the TSO, and maybe in the future by the DSO too, given that the article is not restrained to the transmission system only. The RRC also facilitates to some extent the use of new flexibility resources. Indeed, article 319 RRC governs how consumption or small production units may provide system services. However, to offer these services, these units must have the required technical capability and may not use the same capacity for interruptible load in the same direction (injection to or withdrawal from the grid)[358]. This limits the option for such installations to achieve benefit stacking activities and thus to increase profitability, as is the case in the UK [359]. Secondly, ERSE authorised a pilot project in 2019 for the participation of consumption to the balancing market of regulation reserve [360]. Originally limited to one year, the pilot was extended in April 2020 given its positive results [361]. The duration of the extension was not specified, but it should last until the MPGGS is updated to integrate the new EU provisions [362]. During the consultation procedure prior to this pilot, the sole DSO in mainland Portugal, *EDP Distribuição*, requested an increased TSO-DSO cooperation regarding data exchange and the activation of the consumption facilities connected to its grid [363], as EU law actually requires [364]. Although the situation is evolving, it can be concluded that Portugal is lagging behind the UK and Denmark when it comes to opening its balancing markets to new flexibility resources.

4.3.2 Regulating enablers: smart meters, energy storage, DR and aggregation

The Portuguese legal developments with regard to these four enablers are analysed below, in the same order as in earlier sections.

4.3.2.1 Smart meters

ERSE published in May 2021 a regulation providing that system operators are responsible for buying and installing smart metering equipment [365]. These meters have to comply with Ordinance 231/2013 [366]. This Ordinance provides for the technical requirements and functions of smart meters and the rules for information sharing and billing [367]. It also determines the process for the prior cost-benefit analysis as required in EU law [368]. According to article 2 (c), a smart meter is an equipment measuring the electricity flow and used to manage the related data in order to favour an active participation of the consumer to the electricity supply market. This definition therefore does not only rely on the technical capability of the smart meter but also on its aim: allowing the involvement of consumers in the electricity system. The technical requirements are detailed in annex I of the ordinance and specify that smart meters must realise a 15-minute measurement at least [369]. If all smart meters are indeed deployed with a 15-minute measuring and settlement capability, then, as explained earlier in the UK section, this would allow a wide use of distributed flexibility resources [370].

The first cost-benefit analysis realised in Portugal in order to assess the opportunity of deploying smart meters was negative. However, the second cost-benefit analysis of 2015 provided some positive results and the deployment started shortly after [371]. By January 2021, more than 50% of all connection points in the country where equipped with a smart meter and the target for a full deployment is set at the end of 2024 [372].

4.3.2.2 Energy storage

The Portuguese NECP refers to energy storage as it states that the country will "continue to focus on reversible pumping systems in hydroelectric plants and to try and develop other technological solutions, which include using battery and hydrogen technologies"[373]. This objective corresponds to the aim to "[c]reate a legal framework that makes it possible to promote the implementation of different forms of storage systems, particularly for the electricity sector" by 2020-2021 [374]. In addition, network planning instruments must consider the need to realise investments to facilitate the integration of a greater share of electricity from RESs and of storage assets [375]. However, on the topic of the non-discriminatory participation of technologies and activities such as storage in all energy markets, the document specifies: "not applicable"[376]. All in all, the Portuguese energy policy explicitly considers hydro pumping as the main storage technology to be developed. Electricity storage through batteries may be developed, but this is considered as a secondary option.

The Portuguese legal framework does not contain a definition of energy storage, given that the 2019 E-Directive has not yet been fully transposed in Portuguese law. However, in 2019, DL 76/2019 modified the aforementioned DL 172/2006 and integrated a reference to storage (*Armazenamento*) in its scope [377]. The new version of DL 172/2006 also requires a storage license for standalone storage installations [378]. DL 162/2019 implementing the 2018 RES-Directive entered into force and regulates individual and collective self-consumption, as discussed in SMILE deliverable D7.3 [379]. Hence, self-consumers and renewable energy communities are allowed to own and operate storage installations. It is to be noted that DL 162/2019 also defines the concept of stored energy (*Energia armazenada*) as the electrical energy accumulated in energy storage assets, including EVs when connected to bidirectional charging stations [380]. Although this definition does not replace the required definition on energy storage, it sets the conditions for the use of EVs as storage providers, in a country that has already developed a solid legal framework on EV charging [381]. Finally, ERSE recently approved a new regulation on self-consumption and as part of this refers numerous times to electricity storage, which is explicitly considered as part of the self-consumption process [382]. Article 53 of the regulation also requires network operators to cooperate and share data about electricity consumption, production and storage. Energy storage through technologies other than hydro pumping in Portugal is therefore being legally incentivised for small-sized installations, used for individual or collective self-consumption. These activities may also reinforce the cooperation between the TSO and the DSO.

4.3.2.3 Demand Response & Aggregation

The Portuguese NECP refers in a few instances to DR and aggregation. Yet, it considers DR in a restrictive manner, emphasising that industrial facilities as well as storage in the building sector and industrial sector will be used to provide peak shaving [383]. The document adds that ERSE "has approved the rules for implementing, as of 1 June 2018, two pilot projects, including the introduction of dynamic tariffs for network access in mainland Portugal"[384]. Regarding aggregation, the NECP proposes to add two new roles in the legal framework: market aggregator and demand aggregator [385]. The difference between these roles is not very clear but the demand aggregator comes the closest to the concept of (independent) aggregator as used in EU law and in this report [386]. In addition, similar to storage, the network planning instruments must consider investments in flexibility [387], but the Government estimates that the section on non-discriminatory participation of DR – including via aggregation – in all energy markets does not apply [388].

In legal terms, the lack of transposition of the 2019 E-Directive creates a lack of legal certainty for potential actors interested to engage in DR, including through aggregation. However, DL 162/2019 defines aggregation (*Agregação*) as being an activity undertaken by a singular or collective person, which can be a supplier and combines the electricity produced, consumed or stored by multiples clients buying or selling on energy or system service markets [389]. An independent aggregator is defined as a market participant involved in aggregation but who is not associated with the client's supplier [390]. It is worthwhile highlighting that a market participant can be an operator of DR (*Resposta da procura*) services [391]. This is the only time DR is mentioned in the DL.

The situation that aggregation in Portugal is underdeveloped has been concluded in a recent report stating that:

> Only one aggregator, acting as a [BSP] and only as a pilot project, is currently offering aggregated demand services to the ancillary services markets (regulation reserve market). The only other active aggregators are mediating between renewable energy system generators and the day-ahead and intraday markets, acting as [BRPs][392].

4.3.3 The development of local flexibility markets

The Portuguese NECP barely refers to flexibility. When it does, it is in relation to specific technologies or services, such as storage or aggregation. However, it did not announce or refer to any specific measure. There is, for example, no reference to the development of any market-based procurement schemes for flexibility services. Instead, in one of the few mentions of flexibility, the document states that "new hydroelectric projects equipped with storage capacity and reversibility […] will make an important contribution toward increasing the system's flexibility"[393]. Hence, LFMs are not considered in this key policy document.

Given the lack of transposition of the 2019 E-Directive, the EU law provisions on DSO procurement of flexibility services as presented in section 3.2.3 of this deliverable have not been integrated in Portuguese law.

Despite the above, a recent study in the context of the Portuguese legislation outlined that significant savings can be achieved through LFMs [394]. Also, *EDP Distribuição* indicated in the consultation with regard to the pilot project about the participation of consumption to the balancing market of regulation reserve – as presented in section 4.3.1 above – that the rules to be designed must consider the possibility that, in the future, DSOs procure services from consumption units [395]. Therefore, there seems to be a potential for the development of LFMs on mainland Portugal and a clear interest by its single DSO. If Portugal is to move ahead and develop such markets, at least to the extent required by EU legislation, it could follow the examples of the UK and Denmark and take advantage of the recommendations in this report.

4.3.4 Application of the regime on Madeira

Madeira being an isolated electrical system, benefits from a derogatory legal regime as has been explained before in SMILE deliverables D7.1 and D7.3 [396]. D7.3 also provided an update of the island's energy targets [397] and an analysis of how the provisions in DL 162/2019 on self-consumption have been transposed to the Regional DL 1/2021/M of Madeira [398]. This latter decree of January 2021 contains the same provisions on energy storage as in DL 162/2019 [399]. However, it does not mention aggregation, DR, nor market participants. An analysis of the island's grid code, dating from November 2019, provides the same outcome [400]. The local grid code does not refer to system services either. In addition, it appears from the equivalent of the MPGGS for Madeira – the 2004 *Manual de Procedimentos do Acesso e Operação do Sistema Elétrico Público* – that primary frequency regulation is mandatorily provided by all the power plants connected to the grid, with some exceptions for generation from RESs [401]. The document also specifies that secondary frequency regulation is to be provided by thermal or hydroelectricity generators [402], therefore excluding other technologies and activities such as battery storage or DR aggregation.

It follows from the above and from an interview with the local SMILE partner that there is no balancing mechanism similar to the one on mainland in Madeira. When the network faces a deviation, then EEM either uses the production or those network components it controls to alleviate this deviation. Alternatively, it requests the private generators to increase or diminish their generation. For the future, EEM plans to facilitate the integration of more electricity produced from vRESs by investing in large batteries (at a MW scale) and in the refurbishment of old hydro pumping stations to provide the necessary frequency services [403]. Moreover, the SMILE technologies deployed on the island – small home batteries, EV smart chargers and a low-voltage-grid-connected medium-sized battery (at a kW scale)[404] – can be owned by local consumers, potentially aggregated, and offer local flexibility services. They can for instance offer services where the grid has the least capacity and avoid congestion or voltage issues [405]. In fact, EEM is studying the possibility to establish a common platform where they can aggregate decentralised assets (loads, self-consumers, and/or producers with installed power < 100 kW). If this project goes ahead, it could serve as a basis to develop one or more LFMs on the island. This would be facilitated by the ongoing deployment of smart meters on the island, scheduled to be fully accomplished by 2026 [406]. Be that as it may, any LFM project will require approval by the authorities including ERSE, but also some regulatory changes and a provision providing for a remuneration of flexibility services offered.

4.4 Summary

This chapter has analysed legal developments on balancing, flexibility and LFMs in the three SMILE countries (UK, Denmark and Portugal) and the SMILE islands (Orkney, Samsø and Madeira). Each section focuses on one country and follows the same structure as chapter 3 on EU law. The analyses on balancing include a study of the balancing markets, their integration into European platforms and the procurement of flexibility services from resources connected to the distribution network. The sections on the development of flexibility enablers investigate the targets and deployment of smart meters, the legal regime and use of energy storage technologies and the development of DR and aggregation activities. Next, the existing and potential development of LFMs in each country is assessed, as well as the barriers. Finally, these elements are discussed in relation to the SMILE islands.

Balancing markets

The balancing markets in the SMILE countries present a wide variety of setups. The balancing market landscape in the UK is quite complex and is changing fast. In 2020, a new FCR market (called DC) was launched to facilitate the procurement of flexibility services from battery storage. In comparison, the Danish balancing markets lack such a tailored marketplace but at the same time can make use of several markets where asymmetrical products from as low as 300 kW can be exchanged. The Portuguese system is less developed, in the sense that part of the balancing services must be provided free of charge by producers, which impedes the creation of markets for these services. Moreover, when services are remunerated, BSPs can only use hydroelectricity or thermal turbines, which hinders the development of flexibility services from vRESs, storage and activities such as DR and aggregation.

Both Denmark and Portugal are involved in most of the European platforms that are being created. While Denmark is not involved in TERRE, Portugal is not participating in the voluntary FCR platform. Great Britain's TSO was supposed to take part in both MARI and TERRE but decided to suspend its participation due to Brexit. In all cases, including the UK, the participation (or the perspective thereof) in these platforms has enabled the harmonisation of existing requirements for balancing services towards day-ahead markets with a 1-MW minimum bid size. However, if possible, these platforms should follow the Danish example and lower the minimum bid size and require only asymmetrical products. This is important to facilitate the effective use of the aforementioned flexibility technologies and activities.

The UK is the SMILE country that has made the most progress towards the procurement of distributed flexibility resources by the TSO. Indeed, the new DC market mentioned above is tailored for this purpose. This day-ahead market allows for benefit stacking by storage operators and is quite successful in fostering a positive business case for energy storage. However, rules are needed regarding the priority activation of these flexibility resources by the TSO or DSO. In comparison to the UK, the procurement of balancing services from local flexibility resources has not really taken off in Denmark and Portugal. In Denmark, low balancing prices and the lack of a specific market for local flexibility resources (e.g., batteries) are proving to be considerable barriers. In Portugal, balancing services are exclusively provided by thermal and hydroelectric generators, with vRESs, storage or demand excluded from procurement. In addition, primary reserve is not remunerated. Nevertheless, there are some positive signs. Since 2019, network operators must facilitate the participation of self-consumers in system service markets, directly or through aggregation. To encourage such participation, the RRC – a regulatory document – still needs to be revised to authorise asymmetrical system services offered by consumption or small generation units. In parallel, a pilot project on consumer participation in the balancing market has yielded positive results.

Enablers

The introduction and use of smart meters in the SMILE countries follows three different paths. Denmark was already very close to a complete rollout by end of 2020, while Portugal reached 50% and the UK 42% by the same date. Portugal aims for full deployment by the end of 2024. For the UK, our research only showed a target for a complete rollout for advanced smart meters by October 2025, logically including the replacement of already installed "regular" smart meters. The difference is significant, as advanced smart meters allow for a half-hourly settlement while the others do not. By the end of 2020, only 1.3 out of the 23.6 million installed smart meters in the UK were in fact considered to be advanced meters. In Denmark and Portugal, smart meters are compatible with a 15-minute settlement, as required by EU legislation and as is necessary to harness distributed flexibility resources.

When it comes to storage, the regimes in the three SMILE countries have not significantly changed since deliverable D7.1. The main changes provided some clarifications, for instance as the result of the transposition of the relevant provisions in the 2019 E-Directive. This is the case in Denmark, where the legal framework has gained in clarity since this transposition at the end of 2020. However, according to Danish energy policy documents, the concept of energy storage mainly refers to imported pumped hydro and, in addition, most of the services offered by batteries are not or not sufficiently remunerated. In Portugal, the 2019 E-Directive has not been transposed into national law yet, even though the deadline for doing so has expired. The legal regime thus remains underdeveloped, although recent reforms provide a basis for implementing the concept of storage in Portuguese law. As in Denmark, energy policy documents only consider pumped hydro as energy storage. Batteries are considered secondary and hypothetical. Due to Brexit, the UK did not have to transpose the 2019 E-Directive. Yet its regime follows the same logic as in the EU. Storage (through batteries) is developing fast there, partly thanks to the success of the aforementioned new DC market. The UK provides an interesting and valuable model for the development of energy storage as a means of providing flexibility services.

With regard to DR and aggregation, the three countries are still in the preliminary phase. In the UK, aggregation is possible for most balancing services, but participation of independent aggregators in balancing markets is limited. The provision of DR services by aggregators needs to be further facilitated by legislation. In Denmark, the NECP indicates that the electricity market is open to participation of DR, including via aggregation. Aggregation has recently been defined in law, but DR has not. The development of DR and aggregation has so far been slow in Denmark, as various barriers exist for independent aggregation of flexibility resources. Portuguese law does not define DR, but it defines aggregation in a fairly similar way to EU law. In spite of this, the country's NECP holds a restrictive view of DR, and aggregation has not developed any further so far.

LFMs

The legislation and the level of development of LFMs in the SMILE countries varies. In the UK, legislation for LFMs has not really been developed, but the NRA (Ofgem) and the competent ministry (BEIS) have been pushing for the DNOs (represented by ENA) to procure more flexibility services via market platforms. As a result, LFMs are being used across Great Britain since 2018 and ENA has published a standardised methodology for the procurement of congestion management. If the deployment of LFMs proves to be insufficient, legal measures will be taken. Denmark is rather the opposite of the UK: it has recently developed a sound legal framework but lacks implementation. The Danish legal framework is the result of the transposition of the 2019 E-Directive. In this sense, it respects the elements developed in chapter 3 of this deliverable. The main procurement rules are part of an Executive Order and consist of three phases: (i) advertising the requested services, (ii) providing free and equal access to the market for all qualified parties, and (iii) selecting the best offers based on price. At the time of writing, the impact of this regime was not yet clear, as LFMs seemed to have been used only in pilot projects, and our research also did not provide any proof of an organised system of flexibility service tenders by Danish DSOs. In Portugal, LFMs are not present in either law or practice. Nevertheless, there is potential in the country and the DSO on the mainland has expressed interest in procuring such types of services. However, the first step in this direction is the transposition of the 2019 E-Directive.

All three SMILE islands show real potential for the development of LFMs. Orkney already experiences congestion issues within its internal grid, leading to high curtailment rates for local wind turbines. The relevant SMILE technologies on the island could be expanded and further utilised if the DNO (SSEN) were to establish an LFM. SSEN has also identified the need for voltage control services in order to cope with the increase in generation from vRESs. These services could also be provided through a dedicated LFM. On Samsø, the SMILE technologies deployed in the Ballen Marina face several barriers impeding its participation in flexibility markets (e.g., size requirements and export limits to the distribution grid). Given the island's ambitious decarbonisation policy, an LFM could be created in order to facilitate this transition. The island of Madeira finds itself in a very specific situation due to its distance from the mainland. For instance, there is no balancing market on the island, and the provisions in national law on self-consumption have been transposed to Madeira without the concept of aggregation. For the future, EEM plans to facilitate the integration of more electricity produced from vRESs by operating large batteries and hydro pumping stations to provide the necessary frequency services. It is also developing a platform that should provide potential market parties with information about flexibility needs. This could be the first step towards an LFM. The SMILE technologies deployed on the island could foster the emergence of new FSPs there as well.

Last but not least, this chapter also contains a number of recommendations for the development of LFMs in the SMILE countries (and in other EU MSs). Most of them are based on the UK experience, but they may also be relevant to other jurisdictions. First, national legislators and regulators should consider the procurement of flexibility services and the deployment of LFMs in a holistic manner. If authorities adopt a silo-based mindset, evaluating reforms on an economic basis without integrating the overarching goal of decarbonisation, these reforms could actually delay the decarbonisation process. Second, the experience from a pilot LFM in Cornwall has shown that an LFM operated by a third party, where DNOs and TSOs buy flexibility, is possible. Of course, such a system must be tailored for its specific purpose, which includes ensuring that conflicting resources are not simultaneously dispatched or create new congestion. Third, standardisation of flexibility products is an objective of the national energy policy in the UK. Feedback from a 2017 flexibility services tender has shown that bid criteria can go as low as requesting a 100-kW minimum bid size, a relatively easy-to-reach threshold for distributed flexibility resources. Such a model may serve as an example, but the possibility of establishing standards must be thoroughly studied by the authorities. Indeed, as SMILE partners and the literature have highlighted, some flexibility services are very dependent on local conditions and cannot be provided over long distances. Constraining standards may not help to create LFMs for these types of services. Lastly, British DNOs are using flexible connections to expand and accelerate the connection of vRESs in grid-constrained areas. Following the "last connected, first curtailed" principle, these new installations may suffer from a higher-than-expected level of curtailment, as happened in Orkney. In addition, flexible connections may disincentivise the use of LFMs as DNOs can simply curtail the installations without compensation. Flexible connections could also impede the development of more distributed generation from vRESs, given the lack of financial security. Therefore, NRAs should control the use of flexible connections and adopt the aforementioned holistic view in this process.

5 Conclusions & Recommendations

This deliverable investigates how the stability of electricity networks can be maintained when they have to integrate increasing volumes of electricity produced from vRESs by installations that are often connected to the distribution grid. At national level, TSOs have to cope with this variability in order to maintain network balancing. Apart from traditional methods (e.g., relying on reserve capacity), TSOs can use flexibility resources, including resources connected to the distribution network. At local level, DSOs will increasingly procure flexibility services to deal with issues such as congestion or voltage dips on their network. In both cases, the deployment of enablers such as smart meters and energy storage is a necessity. This deliverable presents an in-depth study of the legal regime for balancing and LFMs as well as their enablers in the EU and in the three SMILE countries.

First, balancing markets in the EU have been harmonised by the 2017 Electricity balancing guideline. These markets are operated by TSOs, which are also the sole buyers of balancing services offered by BSPs in order to resolve the imbalances created by BRPs not adhering to their production or consumption schedules. National balancing markets are in the process of being interlinked through European platforms to pool balancing resources and reduce balancing prices. Denmark and Portugal are part of almost all of these (upcoming) platforms, and Great Britain was on its way to integrate two of them before Brexit.

Secondly, as we make progress in the transition to vRESs, TSOs will need to procure more balancing services provided by flexibility resources connected to the distribution network (hereafter referred to as distributed flexibility resources). Flexibility is a new term introduced in EU law by the Clean Energy Package. Flexibility services are broader in scope than balancing services. They refer to the ability to increase or decrease electricity generation or consumption as requested by flexibility service buyers, including TSOs and DSOs. They include balancing services, but also non-frequency ancillary services, congestion management services or grid investment deferral services.

Thirdly, to increase the quantity of distributed flexibility resources used to provide flexibility services, enabling technologies and activities need to be regulated. These enablers are smart meters, energy storage, DR and aggregation. The 2019 E-Directive and 2019 E-Regulation have either reinforced existing legal regimes or introduced new regimes for these technologies and activities. These are now all defined in the 2019 E-Directive. The corresponding transposition into national law for EU MSs is on its way. The UK has also made some progress, for instance by launching a balancing market tailored for the supply of services from battery storage installations.

Fourthly, according to the 2019 E-Directive, DSOs must create markets for the procurement of non-frequency ancillary services, of energy to cover their energy losses and of flexibility services (if they want to procure flexibility services at all). There are exemptions, but the rationale is that DSOs have to develop LFMs to procure flexibility services for the operation and development of their grid. The services that could potentially be exchanged on LFMs fall under various legal qualifications. In addition, the technical and geographical context varies and influences local service needs. These elements may therefore lead to the creation of several LFMs with different rules. Nevertheless, the actors in an LFM will follow the same architecture of roles as that in a balancing market, albeit with some adjustments. In essence, the system operator buys services provided by FSPs. However, the system operator here is the DSO, not the TSO, and FSPs are expected to rely substantially on aggregation.

At national level, only the UK is using LFMs. Guided by the ministry and the regulator, DNOs have developed LFMs since 2018 to procure a variety of flexibility services. In Denmark, the legal framework has recently improved with the transposition of the 2019 E-Directive, but so far only pilot LFMs are being deployed. In Portugal, the delayed transposition of the 2019 E-Directive has a negative impact on the potential creation of LFMs.

With regard to the SMILE islands (Orkney, Samsø and Madeira), the research shows that despite their different situations, these islands are well suited for developing LFMs. Orkney's grid suffers from internal congestion issues, Samsø aims to achieve 100% of renewable energy consumption by 2030 and its DSO may therefore welcome increased local flexibility and Madeira's main stumbling block on its way to a 100% RESs' fuelled island is ensuring grid balancing. The case of EEM studying a platform for flexibility needs that may evolve in an LFM in the future is to be highlighted. In addition, the SMILE technologies being deployed on the islands represent various enablers to accelerate this transition.

Considering the above, we make the following three series of legal recommendations relating to (i) the use of distributed flexibility resources for balancing service, (ii) the regulation of enablers and (iii) the development of LFMs. These recommendations rely on the timely transposition of the 2019 E-Directive into national law. This transposition was due by the end of 2020, but by June 2021 most of the Directive had not yet been transposed into Portuguese law, including the relevant transpositions for this deliverable. The European Commission can impose legal sanctions when a directive is not transposed or is insufficiently transposed by EU MSs. We reiterate the importance of such procedures given the importance of the key provisions in the 2019 E-Directive relevant for mobilising distributed flexibility resources and developing LFMs.

Improved access of distributed flexibility resources to balancing markets

In order for TSOs in the EU to be able to use as much distributed flexibility resources as possible, the access of these resources to balancing markets should be improved. To achieve this, we make the following three proposals:

Firstly, the 2019 E-Directive, the 2019 E-Regulation and the relevant EU network codes (EB GL, SO GL, RfG NC and DC NC) should be amended in order to ensure effective access to balancing markets by market parties offering distributed small to medium-sized solutions based on storage, DR and aggregation. To this end, these technologies and activities must be expressly authorised in all the aforementioned network codes as well as in the TCMs stemming from these codes. Lowering the product requirements (e.g., with regard to the minimum bid size) could also be useful. This requires some further investigation by ENTSO-E and the EU DSO Entity.

Secondly, balancing platforms are being developed on a European (pan-national) scale. However, such a development may be detrimental to the supply of balancing services offered by small and medium-sized installations on a local level, even when aggregated. It may therefore be relevant to introduce a mechanism such as a locational tariff to give value to locally available flexibility resources.

Thirdly, clear and detailed rules are needed to organise priority activation of distributed flexibility resources by TSOs or DSOs. Currently, it seems that the SO GL is prioritising TSOs to activate flexibility resources for balancing markets, albeit with a veto right for DSOs in charge of the networks to which the resources are connected (the so-called reserve-connecting DSOs). Moreover, the network codes require DSOs to provide data to TSOs with regard to the installations connected to their network. TSOs do not have the same obligation towards DSOs. The network codes should be amended in order to request a bidirectional exchange of data (from TSOs to DSOs and vice versa). Indeed, DSOs may also be interested in data managed by TSOs, especially if DSOs are to create LFMs. In addition, the rules on data sharing need to be harmonised. At present, some DSOs share data on a 15-minute basis, while others do it daily, weekly, monthly or apparently not at all.

Regulate enablers

Increased use of distributed flexibility resources can be facilitated by amending the rules for enabling technologies and activities such as smart meters, energy storage, DR and aggregation.

Smart meters are an important means of facilitating the energy transition at the lowest possible cost. To fulfil their role, they need to equip all metering points and provide for a settlement time that is compatible with the possibility of offering services to flexibility markets (including balancing markets and LFMs). In Denmark, the rollout of smart meters was almost completed by the end of 2020. In contrast, Portugal and the UK still had to equip at least half of the metering points with a smart meter at that time. This transition process to smart meters should be completed as soon as possible. Regarding the settlement time, the 2019 E-Directive provides in article 20 (1) (g) that smart meters "shall enable final customers to be metered and settled at the same time resolution as the imbalance settlement period in the national market." This imbalance settlement period is harmonised at EU level by article 53 (1) of the EB GL. According to this provision, TSOs had until the end of 2020 to apply an imbalance settlement period of 15 minutes. The European Commission, with the help of ENTSO-E, should verify whether this is the case. In principle, the smart meters installed in Portugal and Denmark allow for this 15-minute settlement. However, in the UK, which is no longer bound by EU law, only a fraction of the installed smart meters is considered advanced and can facilitate half-hourly settlement periods. Ofgem and BEIS appear to be addressing this issue, but they must ensure that the UK achieves the full rollout of advanced smart meters by the end of 2025 as scheduled.

Energy storage covers a range of technologies to provide flexibility services and allow further penetration of vRESs. At EU level, the EB GL and corresponding TCMs should be amended to allow for a balancing market design that facilitates the participation of energy storage (e.g., through batteries). The UK provides a very instructive example of such a market with its Dynamic Containment market launched in October 2020. This platform requires asymmetrical products and permits battery storage operators to engage in benefit stacking, thus reinforcing their business case and allowing them to offer services where they are most needed (and therefore most remunerated). Denmark also provides an interesting example with its 300-kW minimum bid size on some balancing markets, a threshold more accessible to medium-sized and aggregated storage installations. The possibility of using such facilitating product requirements as standards in balancing and other flexibility markets in the EU should be studied.

DR and aggregation are not as far advanced in the EU as they have only recently been integrated into EU and MS law. As a next step, the barriers they face will need to be addressed. Various reports from 2020 have shown that DR and aggregation are limited in all three SMILE countries for different reasons (e.g., inadequate regulations or market conditions). Most of the measures needed to address these issues are expected to be taken at the level of network codes and TCMs as well as at national level.

Develop LFMs

In the EU, LFMs have mostly been initiated as pilot projects. Given the lack of experience, EU MSs can use the existing balancing markets that have been functioning for a longer period of time as a model. Therefore, some of the recommendations provided for the access of distributed flexibility resources to balancing markets could also apply to LFMs. This is especially true for access to the market of (aggregated) small producers and DR as well as TSO-DSO coordination. Improved TSO-DSO coordination rules could also be extended to DSO-DSO coordination when relevant (i.e., when a DSO uses the flexibility resources connected to the network of another DSO). Currently, there are no rules in EU law on such coordination. It may be an idea to at least amend the relevant network codes for this purpose.

LFMs organise the market-based procurement of flexibility services. To enhance legal certainty at EU level for the procurement of such flexibility services, we believe that the concept of “flexibility service” should be defined in the E-Directive. As an added benefit, any misunderstanding or confusion with the notion of ancillary services would thus be avoided.

In addition, national legislators and regulators should take a holistic view of procurement rules applicable to flexibility services and the deployment of LFMs. If authorities adopt a silo-based mindset, meaning that they assess reforms on an economic basis without integrating the overarching objective of decarbonisation, these reforms could actually delay the decarbonisation process, which is a fundamental target of EU energy policy. If the best economic and environmental solution is to develop market-based instruments and to level the playing field, this should be the way forward. Otherwise, other, possibly non-market-based schemes, such as administratively set prices, should be taken into account.

For LFMs to be widely used, harmonised operating rules are needed. If DSOs follow the example of balancing markets, they will operate LFMs themselves, just as TSOs do with balancing markets. However, this may raise questions regarding neutral market operation and would require an amendment to the unbundling regime. Another option would be to delegate the operation of the market to a third party, as is already applied in various pilot LFMs in Europe. In that case, the DSO would merely act as the sole buyer (although TSOs may also buy flexibility services on the same marketplace if the LFM rules would allow it). In addition, it would also be possible to create a so-called “common flexibility platform”, a cooperative rule-making body involving all relevant stakeholders.

We also note that balancing markets are increasingly being standardised in order to facilitate BSPs to offer balancing services across borders. It is very likely that LFMs will follow the same trend in order to increase the pool of flexibility resources and reduce procurement costs. Standardisation of flexibility products is already proposed in the 2019 E-Directive, it is a national energy policy goal in the UK and it is mentioned as a possibility in Danish Law. Some standardisation may indeed be profitable for all LFM actors, especially if new standards set reasonable thresholds for the supply of services by involving small and medium-sized resources, including through aggregation. Lessons can be learned, for instance, from a successful flexibility services tender run in the UK in 2017, where the minimum bid size was set at 100 kW, a level allowing distributed flexibility resources to participate. SMILE partner DTI also suggested proposing a generic national LFM setup and then adapting it to local contexts. Within the current EU legal framework, the EU DSO entity could establish guidelines or standards for the creation of LFMs and for the design of standard products. However, LFMs have a “local” component that will sometimes make it more difficult or counterproductive to apply such standards. Indeed, as SMILE partners and the literature have highlighted, some flexibility services are highly dependent on local conditions and cannot be supplied over long distances. Therefore, standardisation should be studied more closely, and it may be a good idea to introduce standardised products in terms of activation time, duration or minimum size when it is advantageous to do so, as in the case of TCMs for the balancing markets.

To facilitate the development of LFMs, legislators and regulators will also have to consider barriers created by external factors. Flexible connections are a good example of this. British DNOs use flexible connections to expand and accelerate the connection of vRESs in grid-constrained areas. Following the “last connected, first curtailed” principle, these new installations can suffer from a higher-than-expected level of curtailment, as happened in Orkney. Flexible connections could therefore impede the development of more generation from vRESs, given the lack of financial security. In addition, flexible connections may disincentivise the use of LFMs as DNOs can simply curtail the installations without offering any compensation, instead of setting up an LFM to buy flexibility. In this case, legislators and regulators should control the use of flexible connections, adopting the aforementioned holistic view in this process.

Many of the abovementioned recommendations can be implemented by adopting new distribution network codes. Indeed, the existing network codes are mainly focused on TSOs, while DSOs have an increasingly important role to play in integrating more production from vRESs and facilitating the decarbonisation process. The legal basis already exists, as article 59 (1) of the 2019 E-Regulation allows for the adoption of network codes on voltage control, congestion management including services provided by active customers, citizen energy communities and the use of aggregation and DR, as well as the supply of non-frequency ancillary services and flexibility services to DSOs.

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